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July 1969

from the . . .
EDITOR'S DESK at

TECHNICAL REVIEW moved back to Corporate Headquarters

The Editor and operation of the Western Union TECHNICAL REVIEW moved back to Corporate Headquarters on August 1, 1969.

Please address all correspondence regarding this publication to:

The Editor of TECHNICAL REVIEW
Western Union, Rm. 1810
60 Hudson Street
New York, N.Y. 10013

The Editor (right) talks with one of our customers, Miss Joan Dailey, of Shields & Co., about SICOM. A satisfied customer is our best salesman. Photo was taken on Wall Street, the heart of the Financial District, in New York City.

Readership Survey

The replies to the Readership Survey announced in the Special A.R.S. Issue in June 1969 are being processed for analysis.

If you have not returned your postcard, in the last page of that issue, kindly return it before Sept. 1, 1969. The July 1st deadline has been extended to Sept. 1, 1969 because of vacation schedules.

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August 9, 1969

Mary C. Killilea

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Technical Review
SUMMER 1969
VOLUME 23, NO. 3

The purpose of the Technical Review is to present technological advances and their applications to communications. This Technical publication is published by Western Union for management, supervisory and technical personnel in Western Union. It is issued quarterly in Spring, Summer, Autumn and Winter. Occasionally, special issues are added to the schedule.

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Vol. 23 No. 3

Summer 1969 Issue

CONTENTS

NCIC Information Retrieval System

Uses

Western Union Terminals and Circuits

A. E. Hildreth

Early in 1966, the Federal Bureau of Investigation completed a study of patterns in crime for the period from 1960 to 1965. This study yielded some disturbing facts:

a. Serious crimes had increased by 46 percent; although the population had increased less than 10 percent over the same period.
b. Only one crime in four resulted in an arrest.
c. Three out of four persons arrested had a previous arrest record.
d. Over half of the repeat offenders were arrested in two or more states.

As a result of these studies, the FBI proposed the National Crime Information Center[1] (NCIC), which allows law-enforcement agencies to rapidly identify mobile criminals and stolen articles to decrease significantly the time utilized in solving crimes. The assistance of an advisory group of the International Association of Chiefs of Police (IACP), was requested to establish standards for use in all law-enforcement computerized information systems. The NCIC would serve as an interstate index on criminals, as well as on stolen property, such as guns, stolen automobiles, cameras, securities and other serialized articles. For example, when a car stolen in one city is noticed hundreds of miles away, some time later, rapid retrieval of information concerning the stolen vehicle is of vital importance to the observing officer if a recovery and arrest is to be made. With conventional procedures, it sometimes took weeks, to determine the answer to an inquiry regarding a stolen vehicle. The NCIC would work with terminals installed in state and major city police headquarters for rapid communication with the NCIC computer.

New Information Retrieval System

Standards for use with the NCIC and all interconnecting law-enforcement computerized systems were adopted by the IACP in October 1966; in January 1967 initial terminal equipment was installed and the National Crime Information Center at FBI headquarters in Washington, D.C. became operational.

The new retrieval system comprised computer equipment and three types of terminals. The equipment at the National Crime Information Center includes at IBM 360 Model 50 computer, with a back-up computer, IBM 360/40.

Two IBM 2702 Transmission Control Units, one for the main processor and the other for the fall-back machine, interface to Western Union's communications lines. Separate hardware modules handle the circuits to the Western Union Model 35 and IBM 1050 low-speed terminals. The 2702 Transmission Control Units, performs the serial/parallel conversions, polls the terminals, provides the required idle line time-outs, and decodes certain received codes to cause interrupts to the computer. Large amounts of mass storage enable the computer to provide rapid access to the various files.

Terminals at federal, state, and local law enforcement agencies may be a Western Union terminal, an IBM terminal or a computer. They provide remote access to the NCIC computer for retrieving information, for entering new data, and for updating old data. Each terminal is connected to the NCIC computer by circuits provided by Western Union.

Transfer Switch

As shown in Figure 1, each circuit terminates in a switching arrangement or Transfer Switch Panel for 32 lines that permits the circuit to be connected to either of the two Transmission Control Units at the computer. One switch is provided for each circuit connected to the computer. This switch connects the circuit to processor #1 or processor #2 on alternate operations. When a circuit or terminal malfunctions, it can be switched individually to standby for troubleshooting without interfering with the on-line processor. A second group of two switches on the Transfer Switch Panel permits all the circuits to be switched simultaneously by operation of a Master Transfer Switch. In the IND (individual) position, the individual circuits are switched according to a preset pattern. In the ALL position, all circuits are switched to either processor, depending on the setting of another switch associated with the master transfer switch.

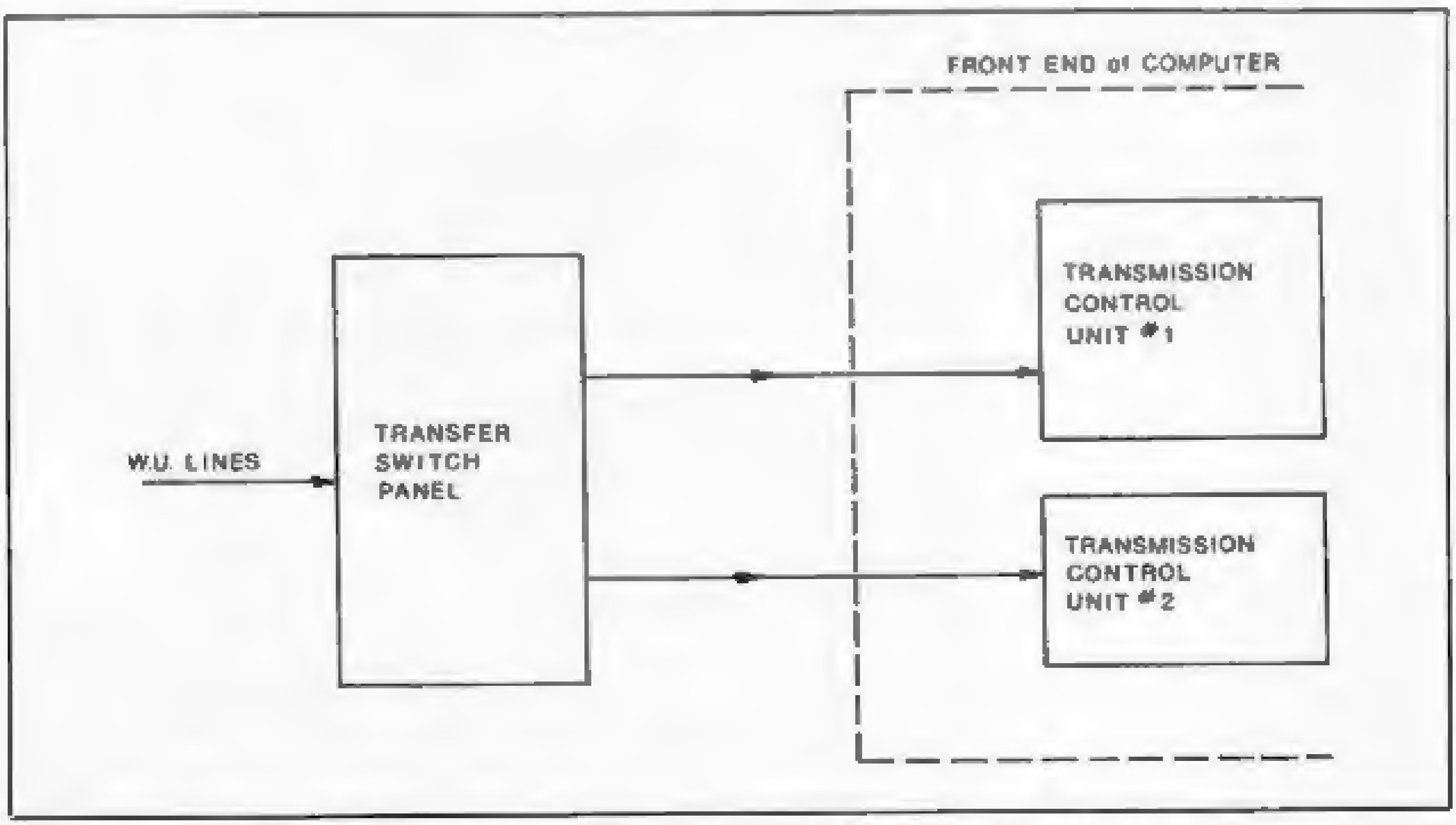

Figure 1—Block Diagram of Interface of Western Union Circuits with NCIC Computer

Western Union Terminals

Besides providing the communication lines to the National Crime Information Center, Western Union also provides the Model 35 ASR terminal, shown in Fig. 2, to many of the user agencies. This terminal provides a page copy of sent and received messages, a keyboard input for inquiries, and a punched tape input to the computer for updating records. Tape may be prepared off-line on the same terminal by connecting the keyboard to the punch while leaving the printer on-line for any message from the computer. The characters are both punched and typed on the tape; thus, it is not necessary for operators to read the punched tape as many of them now do with baudot code. The control unit regulates sending and receiving in response to line signals.

The Western Union terminal, which uses Plan 135 equipment, comprises the following components:

a. Western Union Model 35 ASR set with typing reperforator.

b. Solid-State Selector 11708, with parity error checking.

c. Electronic Modification Kit 12242 to provide two different answerback characters.

d. Modified Control Panel 11705, shown in Fig. 3 to facilitate keyboard entries and to provide a parity error indicator lamp.

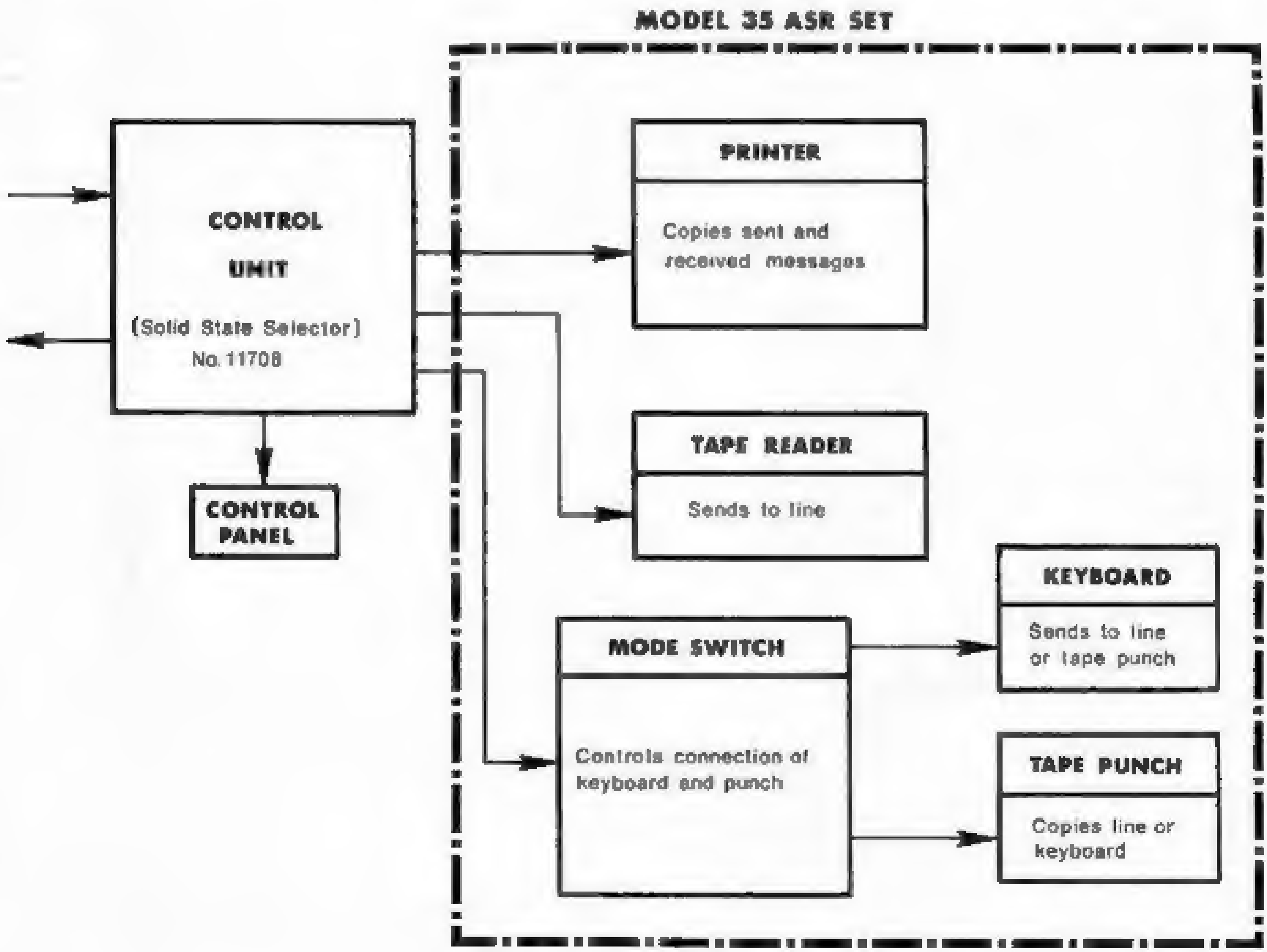

Figure 2—Western Union Terminal

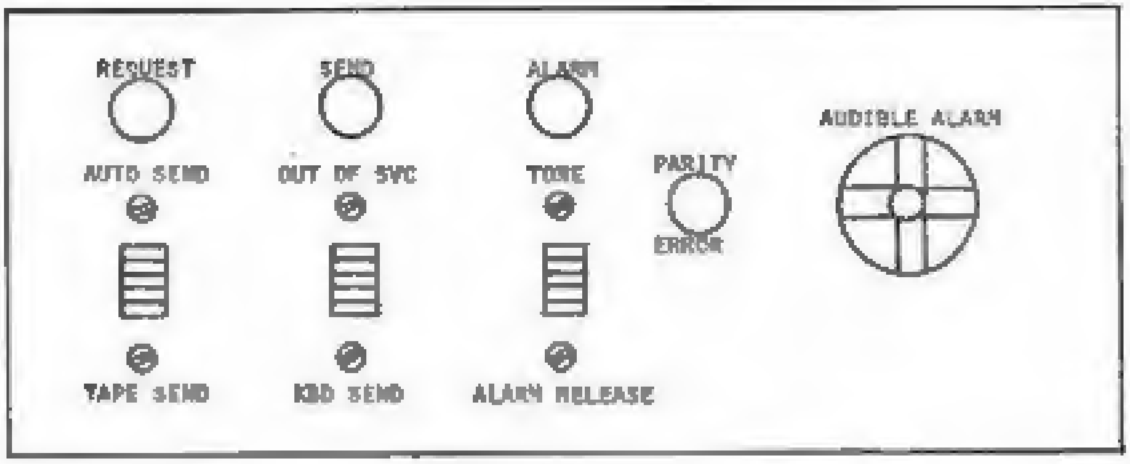

Figure 3—Control Panel

Modified Plan 135 Equipment

While the polling and operating procedures are based on Western Union's Plan 135 Switching System, the Plan 135 equipment was modified so that the following important differences exist:

a. The answerback response characters are the ASCII characters *DC1* an *EOT*. These characters were selected because of hardware character detection characteristics equipment of the IBM 2702.

b. After the invitation-to-send sequence is received, the terminal waits 20 seconds before replying with the "no traffic waiting" response answerback *DC1*. Sending will start anytime a request switch is operated during this 20-second period. This special feature minimizes transmission delays due to polling and reduces the frequency of interrupts to the computer. This period may be reduced to 5 seconds, if terminals are connected on a multipoint circuit.

c. The KBD SEND position on the control panel has been converted to momentary action, to permit storing a single keyboard entry request.

d. While a message is being received from the computer, a parity error will set a storage element and light the PARITY ERROR lamp. At the end of the message, the terminal will generate a *DC1* answerback if no parity error had been received, or an *EOT* if one or more parity errors had been detected.

Messages

The ASCII control sequences used in the NCIC system messages are outlined in Table 1. After each message, either an inquiry or entry, an acknowledgment or reply is printed on the ASR set before the computer polls the terminal for another message. If an input is rejected by the computer, the reason for the rejection is included in the acknowledgment. For example, the reply REJ INV NIC to an inquiry is interpreted as "input rejected for an invalid NCIC code number in the inquiry."

TABLE 1

CONTROL SEQUENCES

FUNCTION	ORIGINATOR	CODE
Sending from Outstation		
Invitation to Send (ITS)	Computer	CAN A*
No Message Waiting	Outstation	DC1
End of Message	Outstation	EOT
Message Cancel	Outstation	CAN EOT
Sending from Computer		
Station Select Code (SSC)	Computer	SOH A*
Ready to Receive	Outstation	DC1
Not Ready to Receive	Outstation	EOT
End of Message	Computer	DLE EOT
No parity Error Detected	Outstation	DC1
Parity Error Detected	Outstation	EOT

* A may be replaced by other characters on multipoint circuits.

There are three types of messages originated, two from the terminal to NCIC and one from the Center. Those from the terminal are (1) inquiries

for information, and (2) entries to establish new records and to update old ones. Messages are handled one at a time. The computer will not poll for a second message until an answer to the first has been returned to the terminal. From the Center, occasional administrative messages are broadcast to the terminals, to advise of NCIC availability.

Inquiries, the first type of message, are generally short, about 40 or 50 characters long. Since they are usually operationally "urgent" they are transmitted directly from the keyboard to the computer. The operator pushes the KBD SEND switch and starts sending when the SEND lamp comes on and the audible alarm sounds. (The alarm is silenced by the transmission of the first character.) The inquiry and reply are printed by the ASR typing unit. Positive responses to inquiries are termed "hits" in this system. These are used by the inquiring agency as leads only. Before any action is taken, verification of the data retrieved is always made with the agency which first entered the record.

Record entries, the second type, are usually longer and follow a somewhat more complex format. These are prepared in punched tape off-line and transmitted in more standard multipoint fashion. Multiple messages may be prepared in a tape by operating the AUTO SEND switch upward. Messages are then accepted by the NCIC individually. Multiple inquiries may also be prepared in tape and handled the same way.

Western Union Class D Circuits

The terminals, connected to the NCIC by Western Union Class D circuits, are terminated in data sets in the computer room. Interface between the computer and the data set is according to EIA Standard RS-232-B.

Growth of the NCIC

The NCIC started in January 1967 with the IBM 360/40 computer and 2702 Transmission Control Units capable of serving 62 lines. Fifteen city and state agencies were connected at that time. The initial file consisted of 23,000 records. In April of that year, additional disc storage was added to expand the system capability. Later, the 2702 Transmission Control Units were replaced by Model 2703 Units to permit more circuits to be added and to handle high-speed communication links. In the summer of 1968, the IBM 360/40 was replaced with an IBM 360/50 for still greater capacity.

As of August, 1969, there were more than 1,154,000 records of all types, including 337,000 vehicle records. The number of transactions averages about 37,000 per day, with a peak day over 45,000. In spite of this volume, response time to input messages averages less than 10 seconds.

In 31 months of operation, the system has expanded from the original 15 terminals to 100 terminals in 48 states, the District of Columbia, and Canada. Of these, 56 are Model 35 terminals, 37 are IBM 1050 and 14 are computer terminals. Over 80,000 air-line miles of Western Union Class D circuits interconnect these terminals to the NCIC computer in Washington, D.C.

Valuable Law Enforcement Tool

The National Crime Information Center is presently providing an extremely valuable tool for law enforcement agencies. The Western Union circuits and terminal equipment extend its service to remote agencies quickly and easily.

Since certain identifiers may be repeated in more than one NCIC record, one inquiry may lead to several entries.

Sometimes, a check on an automobile may even lead to a wanted persons entry, or other record. For example, an excerpt from the *NCIC NEWSLETTER* 68-4, published by the FBI, reports these events in an inquiry from an NCIC terminal in Idaho:

> ". . . . an inquiry on a vehicle resulted in recovery of a 1965 Chevrolet stolen in Alabama, the license plate on the Chevrolet stolen in Missouri, and the arrest of the driver who was identified as an FBI fugitive wanted in California for grand theft; . . . ."

* * * *

Reference

1. The National Crime Information Center—a computerized information system to serve all law enforcement, Don R. Roderick, **Proceedings of the First National Symposium on Law Enforcement Science and Technology**, Thompson Book Company, Academic Press, 1967.

ALAN E. HILDRETH, JR., Manager of Terminal Equipment in the Engineering Group of the Government Communications Systems Department, has been involved in Western Union's efforts in the NCIC since its earliest implementation phases.

Mr. Hildreth joined Western Union in 1945. He was assigned to the company's Water Mill Laboratory, where he participated in various system and equipment developments. He was involved in all phases of the design and implementation of the Bomb Alarm System, and in the design of the Optical Character Reader.

In 1965, he joined Eastman Kodak Company where he designed electronic controls for automatic photographic equipment.

Returning to Western Union in 1966, he has contributed to systems analysis and evaluation. He has also been involved in equipment specification efforts.

Mr. Hildreth received his BSEE degree, with honors, from Northeastern University in 1951. He is a member of Tau Beta Pi, Eta Kappa Nu, and the IEEE. He is co-holder of two patents for telegraphic equipment.

DIGITAL TEST FACILITY - A UNIQUE MEASUREMENT TOOL

G. C. Parowski

Western Union developed a Test Facility which is used as a tool, in Research & Development, to measure the channel transmission of existing plant. This test facility is unique since digital data error statistics and channel analog performance are simultaneously recorded by an on-line digital computer. The computer programs developed for this facility perform error analysis, flag out-of-limit conditions, and provide data compression during real time tests.

This facility is capable of obtaining error statistics resolved to a single bit. At the same time, a history of the signal and the noise fluctuations on an adjacent channel is measured.

The facility is composed of a communications based digital computer, UNIVAC 418-II computer, at 60 Hudson Street, New York City and a special instrumentation system shown in the Block Diagram in Figure 1. The computer is connected on-line for recording and analyzing the data. It is equipped with two types of terminations, a) one high-speed synchronous ($\leqq$4800 bps) unit and b) 4 low-speed asynchronous ($\leq$300 bps) units.

Special Features of the Test Facility

The data channel, shown in Figure 1, has as its signal a pseudo-random bit pattern generator with a sequence length of 2047 bits. The pseudo-random source drives the send data set at 2400 bps with a polar dc signal. Bit timing for the pattern generation is obtained from the send clock of the data set. The send data set converts the polar signal to a modulated audio frequency (AF) signal suitable for transmission over a voice frequency channel (VF). The receive data set accepts the AF signal and converts it to a polar signal. At this point the "pattern comparator" provides a bit-by-bit comparison between the possible errored receive pattern and a locally generated error-free pattern. The error stream output is a chain of zeros and ones, with a "1" signifying an error bit. The error stream feeds the synch character error stream switch.

Another input to the switch is the synch character generator which has the function of generating characters to enable the communication line terminal (CLT) to "get into" character synchroniza

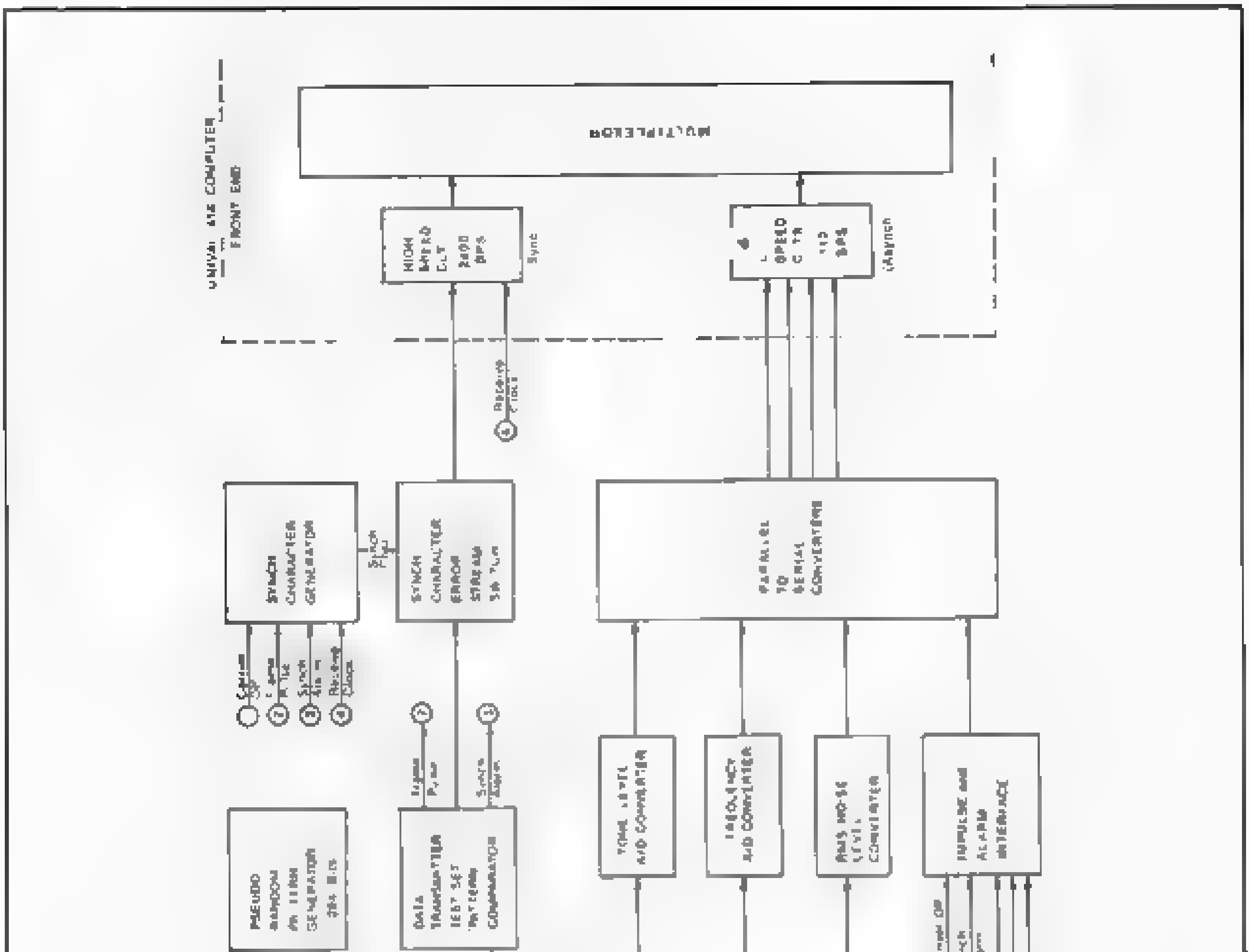

Figure 1—Block Diagram of Test Facility

tion. Immediately after synchronization, and as long as the system is in synchronism, error stream data is collected in the computer. A frame pulse signal is sent from the pattern comparator so that an exact bit displacement exists between the received pattern and the synch characters. Automatic resynchronizing is achieved when the carrier comes up and/or the synch alarm is cleared. The computer interface is that High Speed CLT which takes bits serially and transmits them, 16 bits in parallel, to the computer via the multiplexor.

Adjacent to the data channel a voice frequency channel (VF, Tone) is monitored to determine channel variations during the test run. A 3.2 kHz tone is applied over the VF. At the receive end the tone is picked off through a high pass filter and fed into two analog-to-digital converters (A/D). One A/D converts the tone level to a binary number. The second A/D converts the tone frequency to a binary number. An 8-bit binary number providing 256 possible levels is used. The outputs of the A/Ds go to a parallel-to-serial converter for subsequent transmission to one of the four 8-bit asynchronous, low speed CLT at a rate of 10 characters per second. This sampling rate is sufficient to obtain a history of rms noise, rms signals, frequency, and impulse counts. The instrumentation provides a precision of .2 db for signal and noise level and 2 Hz for test tone frequency. The low pass output of the Splitting Filter is a measure of noise in the VF channel. To obtain a binary representation of the rms noise, an analog-to-digital converter is again used.

The noise band output of the splitting filter is applied to an impulse counter, in addition to the A/D Converter. This counter generates a pulse over one of three output leads whenever the amplitude of an impulse exceeds one of the adjustable thresholds. The pulse appears on the lead corresponding to the highest exceeded threshold. The output rate is strobed into the Impulse and Alarm Interface for inclusion in an alarm character which is sent periodically at 10 cps to the CLT. This is consistent with the impulse counter employed which has a maximum count rate of 10 impulses per second. This alarm character is eight bits long, only six of which are used. Three bits are used for impulse thresholds and the other three are used to signal data carrier off, "a synch alarm," and a 3.2 kHz tone off.

In Figure 1, the Send Data Set, the Pseudo-Random Pattern Generator plus the Oscillator is shown co-located with the receiving instrumentation for loop testing. However, for straight through testing these 3 units may be located at the distant end of the circuit.

Figure 2 is a block diagram of the major elements of the on-line computer. The primary components of the computer include the Standard Communication Subsystem (SCS), the 418 Central Processor Unit (CPU) with console, 1004 printer card reader, three VIC magnetic tape units, and a Day Clock. The 418 CPU was equipped with 32K words of core.

Simultaneous monitoring of signal level, frequency and noise level permits the analyst to correlate errors with signal fluctuations. Thus, major sources of errors can be isolated. The ability of the analyst, to determine the occurrence of errors for a particular bit, is enhanced with this facility because this instrumentation helps determine 1) if the channel is pattern sensitive and 2) if the channel is symmetric. In a symmetrical channel, 0→1 and 1→0 transformations are equiprobable.

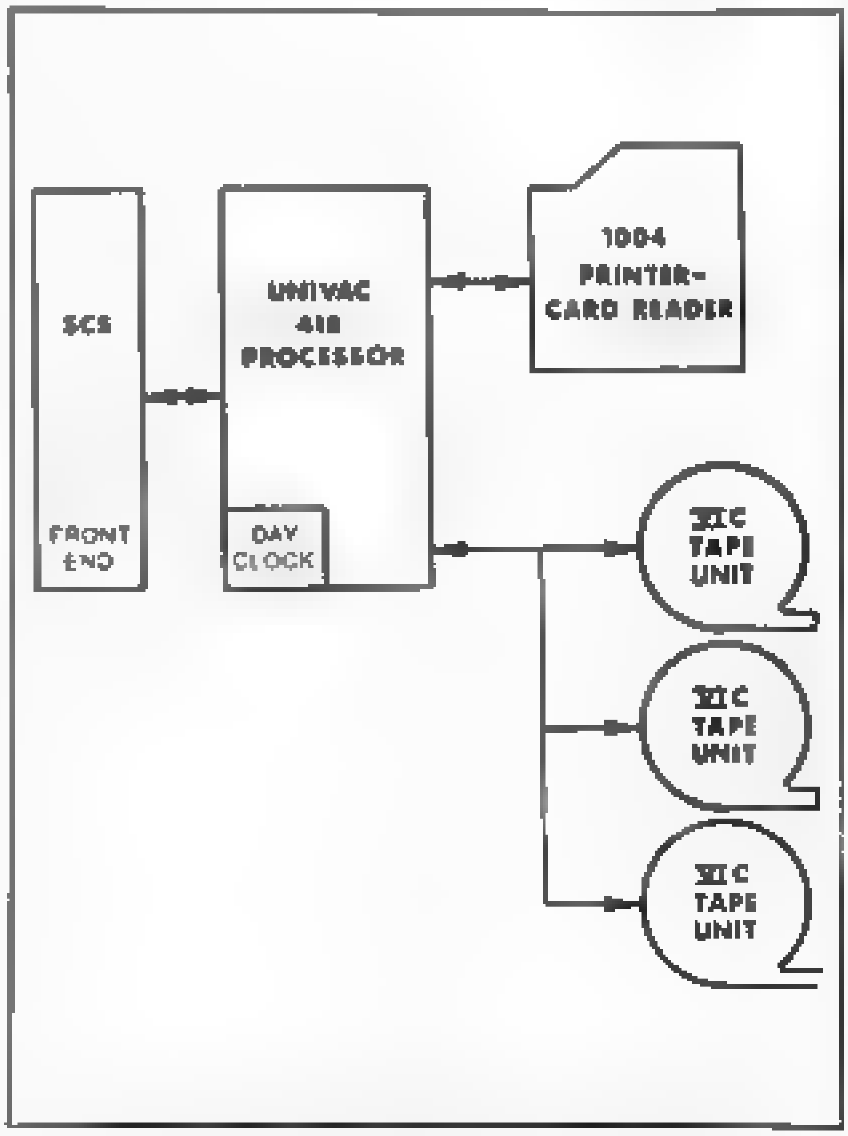

Figure 2—Major Elements of the On-Line Computer

Software

The software package used in the test facility comprises

"The Transmission Real Time Analysis Program" (TRAP), UNIVAC EXEC 50-4, and the Tape Handler Program "TAPHAN." TRAP provides on-line analysis at prespecified time intervals as well as over the entire test period, it also provides data compression. Compression of the error stream consists of keeping a complete sequence of contiguous correct bits and error bits. For example, a sequence of 350 good bits, 3 error bits, and 4 good bits, 1 error bit and 79100 good bits is recorded as 350,,, 4, 79100. Since a test run always starts at a particular bit position in the repetitive pseudo-random pattern, it is possible to denote which particular bit positions are in error. Compression of the low speed data i.e., levels frequency and alarms is accomplished by means of delta recording, or by retaining only those input numbers which differ from the previous number by an amount greater than a specified delta value. Analysis of the error stream consists of:

- Gap Length Analysis—Analysis of the printout of the distribution tables of number of occurrences of particular gap lengths
- Error Burst Analysis—Analysis of the printout of the distribution tables of number of occurrences of various burst lengths
- Error Rate —Analysis of the printout shown on Intermediate Summary shown in Figure 3
- Error Message —An error message is transmitted if a prescribed error rate or signal level is exceeded

A gap length is defined as that series of bits in the data stream that is error free.

A burst length is defined as a sequence of bits that begins with an error bit, ends with an error and within this sequence, the proportion of error bits to total bits exceeds some prescribed fraction (e.g. 3/4).

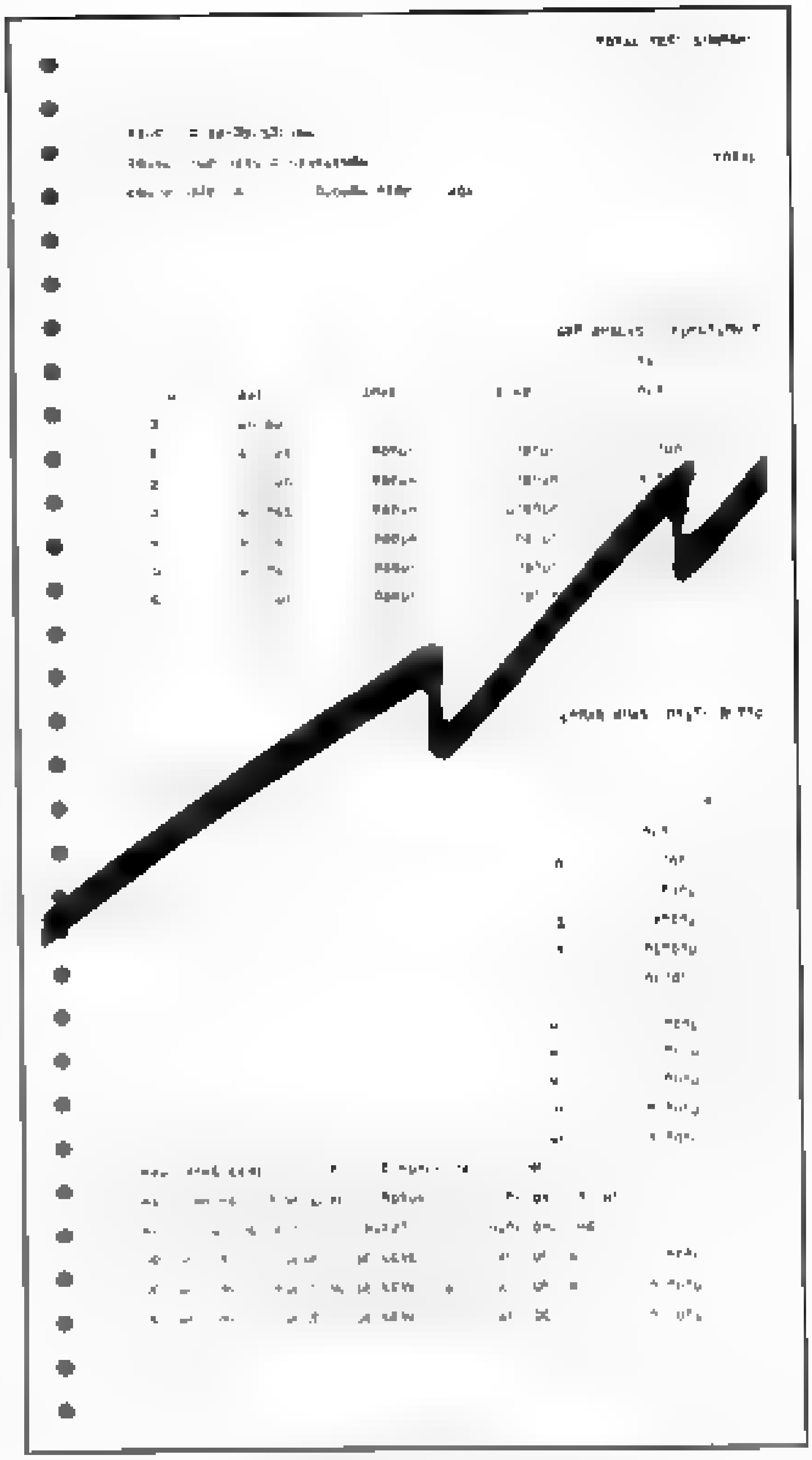

Figure 3—Partial Printout of Statistical Data

A printout of this statistical data is important to the engineer for the design of forward error correction systems, error detection and retransmission schemes, and block interleaving systems.

Analysis of the low speed data consists of averaging the tone level, channel noise level and the tone frequency and providing subtotals of impulse level counts over the adjustable delta period of a test run. In addition, an "out of limits" printout occurs when the tone level, channel noise level or the tone frequency limits are exceeded. All of these are shown in the lower section of Figure 3. The format of the printout in Figure 3 makes the

analysis easy. Figures 4 through 6 are graphs of some of the data collected during one test run, on a New York to San Francisco circuit which was looped back to San Francisco.

Figure 4 was plotted to show the occurrences of errors relative to a block size (576 bits) used in the ISCS-I system. Faced with the line statistics as measured, transmission performance would result in one errored block in 40,000. Figure 5 shows the distribution of error-free intervals. This is an important statistic, since observation can delineate, if the error interval distribution is random or if it displays some periodicity. If periodic errors were present, they would show up as discrete jumps on the curve. However, no such tendency was present in the measured data, shown in Figure 5.

Figure 6 is a histogram of the frequency of error-free intervals in one decade range

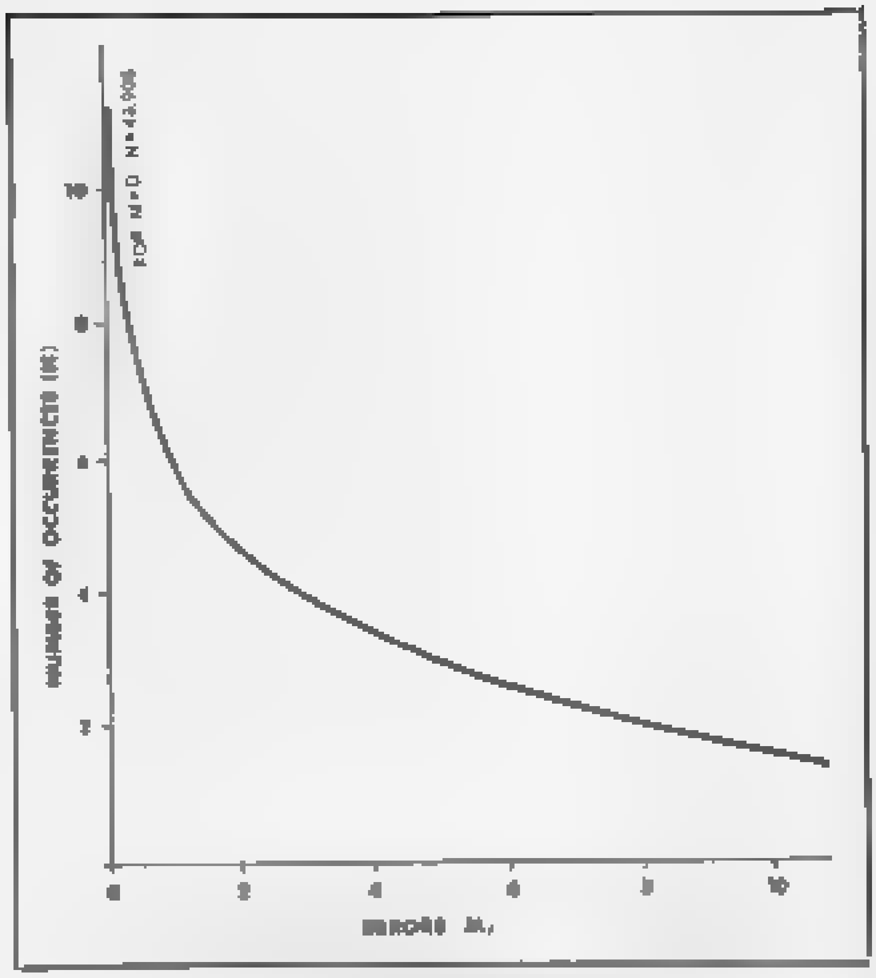

Figure 4—Error Frequency Curve for 576 Bit Block N.Y.—San Francisco Loop

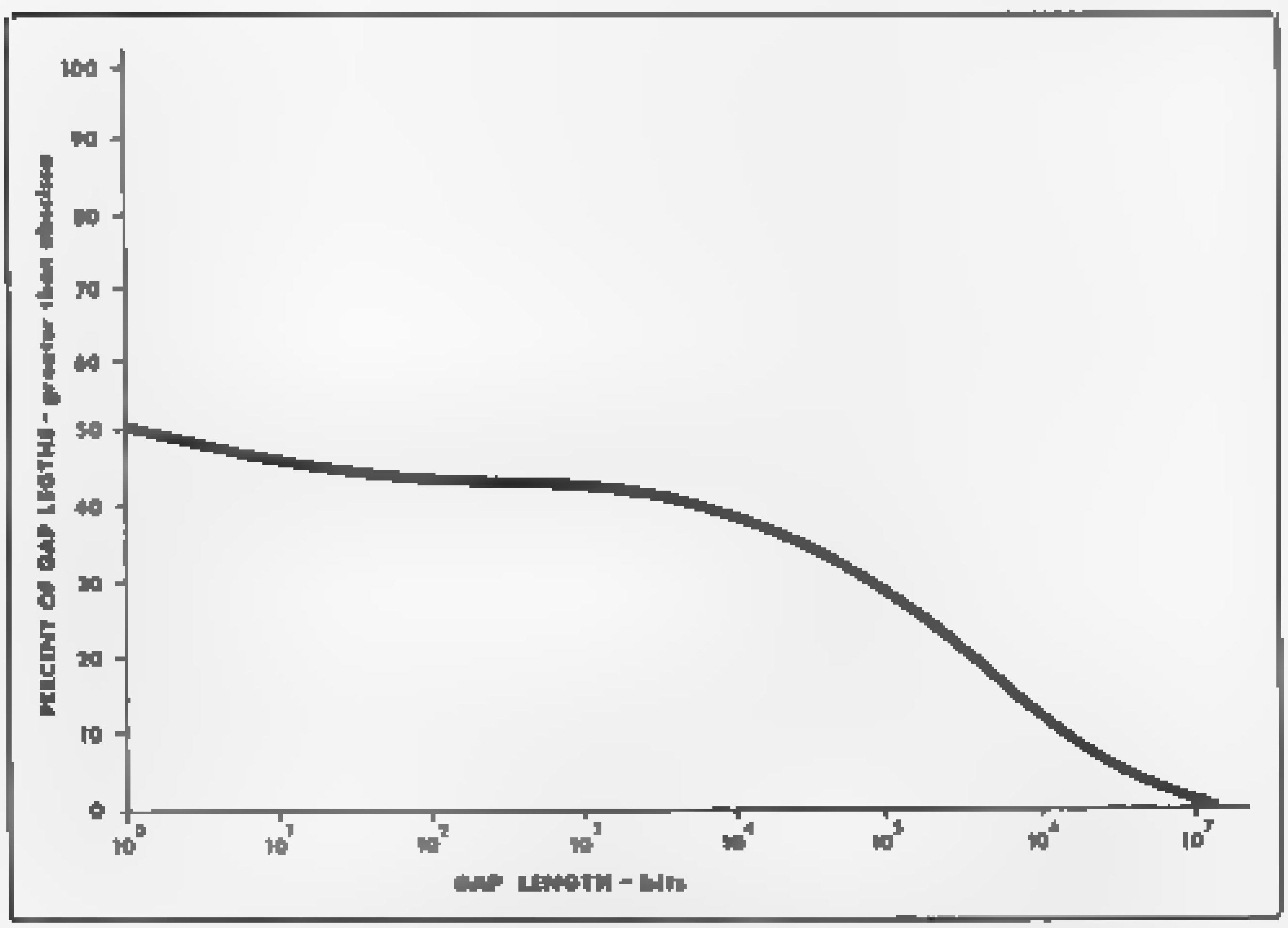

Figure 5—Cumulative Distribution of Error-Free Intervals (Gap Lengths)

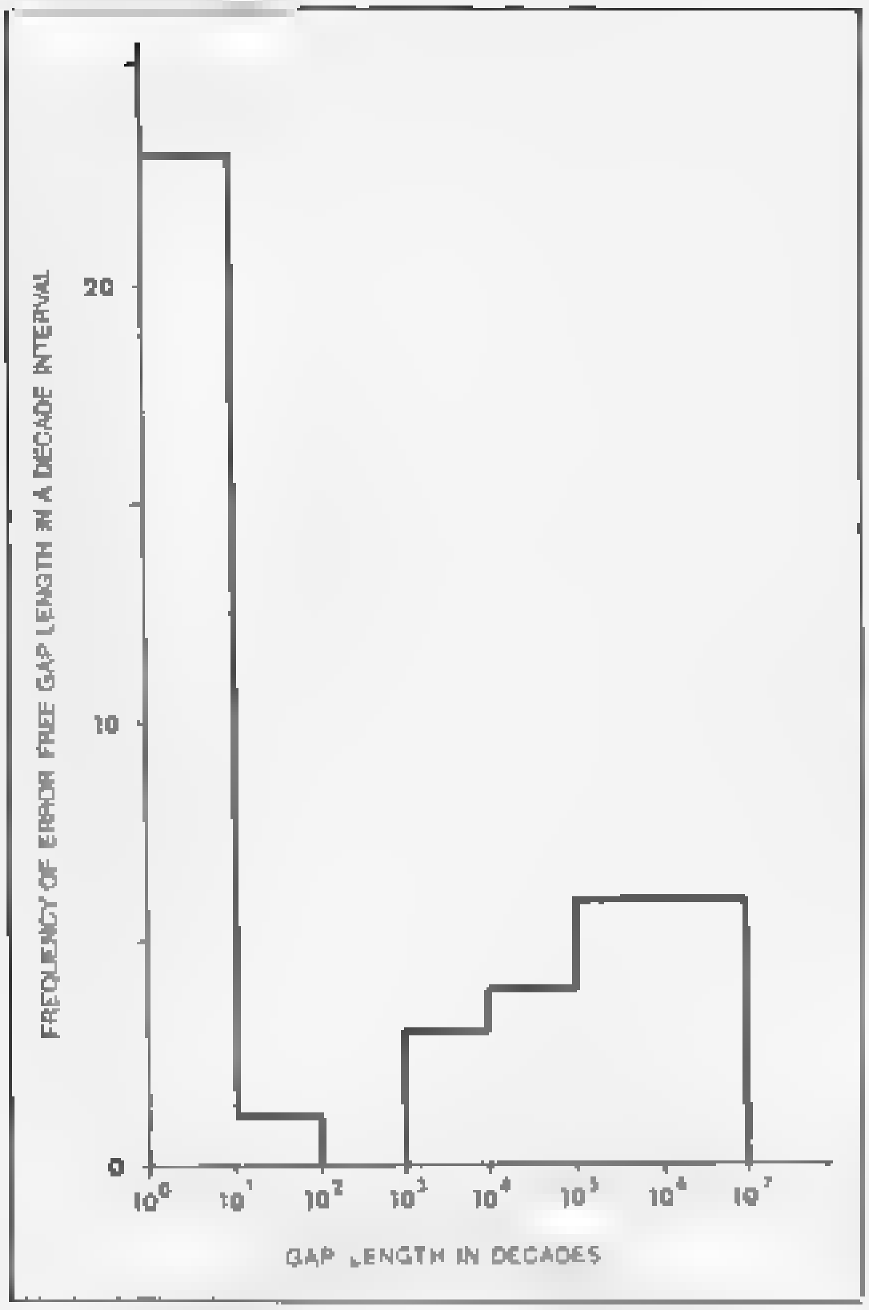

Figure 6—Histogram of Occurrence of Gap Length in a Particular Range

Useful Management Tool

The test facility has proven to be a useful tool, in the past two years, in determining the performance of Western Union data circuits. The tests were made at 2400 bps, however, the facility may be used to test circuits up to 4800 bps. When used for circuits over 4800 bps, a different synchronous communications line terminal must be installed. A UNIVAC Data Line Terminal permits tests up to 50K bps.

When computer time is not available, it is possible to still use the facility, since it is also equipped with an incremental error printer pen recorder and other measuring instruments for monitoring signal levels and alarms.

Acknowledgement

The author wishes to acknowledge the contribution of G. L. Svarczkopf, in the Planning and Engineering Operation, for his help in the design of the test facility.

* * * *

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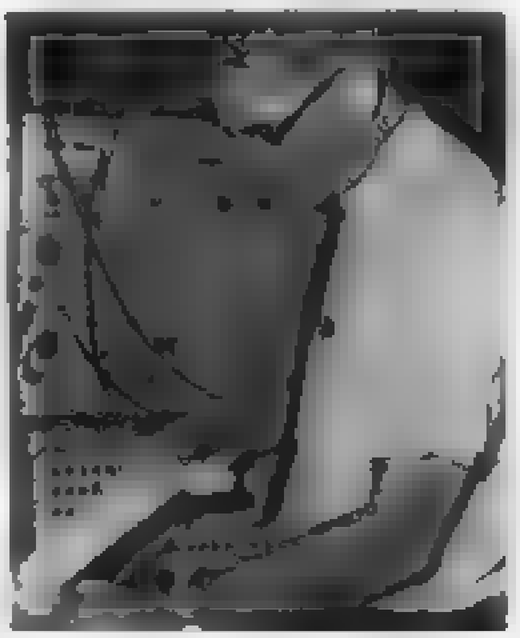
2. S. Ohuler, "Documentation for the Transmission Error Time Analysis Program," Western Union P&EO Document No. 05—September 24, 1968.
3. T. Kleiber and G. Parowski, "Analysis of Data Collected During Doom Error Tests on ISCS Circuit From New York to San Francisco," WU Memorandum dated May 26, 1968.
4. R. Schmer, "Channel Characteristics Affecting Data Transmission," WU Memorandum dated August 15, 1966.

George C. Parowski, Manager, in the Planning and Engineering Operation has been responsible for the design of the digital channel evaluation facility. He is currently involved in the trunking design of the ISCS network and also the interface design of ISCS with external circuit switched networks.

Prior to joining Western Union in 1966, Mr. Parowski was involved in the design and implementation of microwave systems, cable carrier systems, and digital computer test equipment.

He received his B.S. from Seton Hall University and an MS degree in Engineering from Stevens Institute of Technology. He was mentioned in "Who's Who" in American Colleges and Universities and is a Member of IEEE.



SHIELDS & COMPANY

SHIELDS AND COMPANY

The First Customer on Wall Street to Cut-over to SICOM

By Joan C. Dailey
Shields & Company

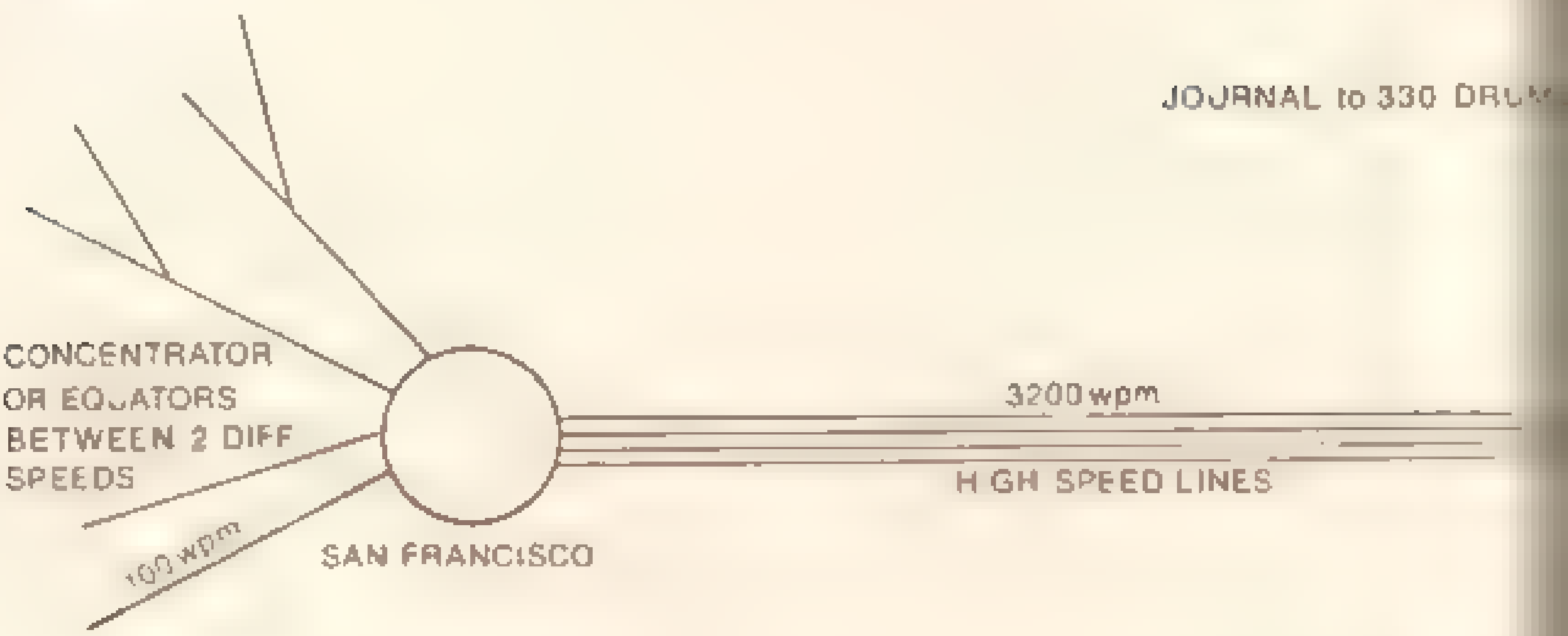
Joan C. Dailey, member of the Communications Department of Shields & Company, has been responsible for the cut-over to SICOM. She has been involved in all the internal procedures for that Firm including the design of forms, the coordination of various branch activities and streamlining the operation to facilitate the cut-over.

Like all firms, with headquarters in the Financial District in New York City, Shields and Company is involved in the office expansion squeeze. Three and four clerks are working in areas designed for one, and *still* there is not enough room. Since our businesses are related—in fact, dependent upon our communications network—expansion forced us to make a decision. Either we would be faced with a multitude of teletypes in our Main Order Room, or because of lack of space, a heavily over loaded wire network—over loaded to the point where just to get on the wire, Branch Order Clerks had to wait 2 or 3 minutes, and then they were required to release the wire after a stipulated number of orders. Before SICOM, it was not inconceivable, on a high volume day, for an order to take 15 minutes, just to get out of the Branch. Needless to say, this does nothing to improve relations with Branch Office Salesmen, who are convinced, anyway, that the Main Office Personnel is out to make life impossible for them. And, if other brokerage firms are at all like Shields and Company, their Main Office Order Rooms serve as the funnel through which all (or almost all) of their traffic passes.

Therefore, as a matter of practicality, over-all firm expansion, at Shields and Company, was limited to the capacity to handle an increased volume—both paper-work-wise, and order-handling-wise. Each of these in turn, boiled down to square-foot floor space.

SICOM Today

SICOM, Securities Industry Communications, is a computer-based, Information/Communications Service, designed by Western Union for members of the Brokerage Community. It provides the user with a shared, real-time, store-and-forward communications system, tailored to the needs of the Financial Industry. It is the equivalent of a dedicated network for the subscriber, without the need for creating and developing his own switching center. The cost relates only to that portion of the system which he uses



At its heart, at Mahwah, New Jersey, are two on-line UNIVAC 418 solid state, digital computers —connected by high speed (2400 baud) lines to concentrator/deconcentrators—known as Dalcodes shown in Fig. 1. Of the many Dalcodes in the system, three Dalcodes at New York City Philadelphia and San Francisco, shown in Figure 2, interface to the low speed (75 baud) lines. which in turn, are connected to the Subscribers' Station Terminals. Each high speed line has the capacity to handle 26 low speed lines simultaneously, while the computers can service a maximum of 21 Dalcodes at once—allowing for 546 duplex transmissions, or 1092 messages in transit simultaneously

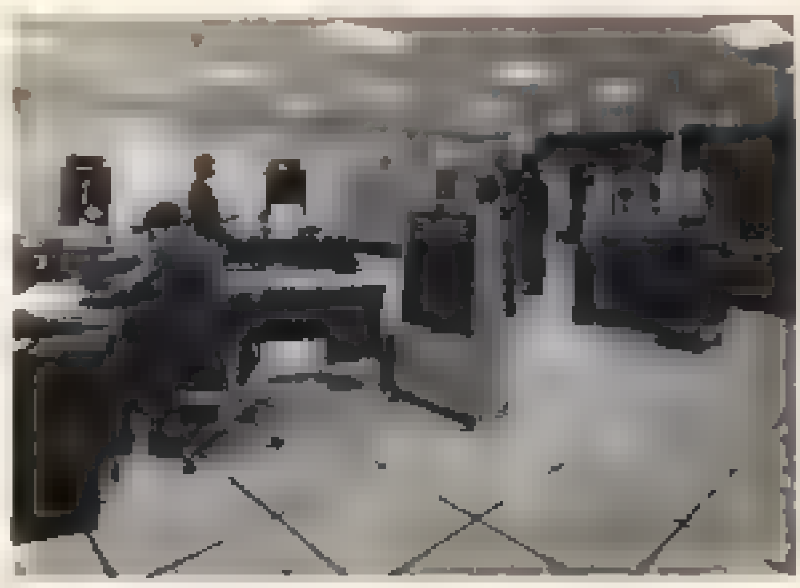


Fig. 1—Installation at Western Union's Technology Center in Mahwah, N.J.

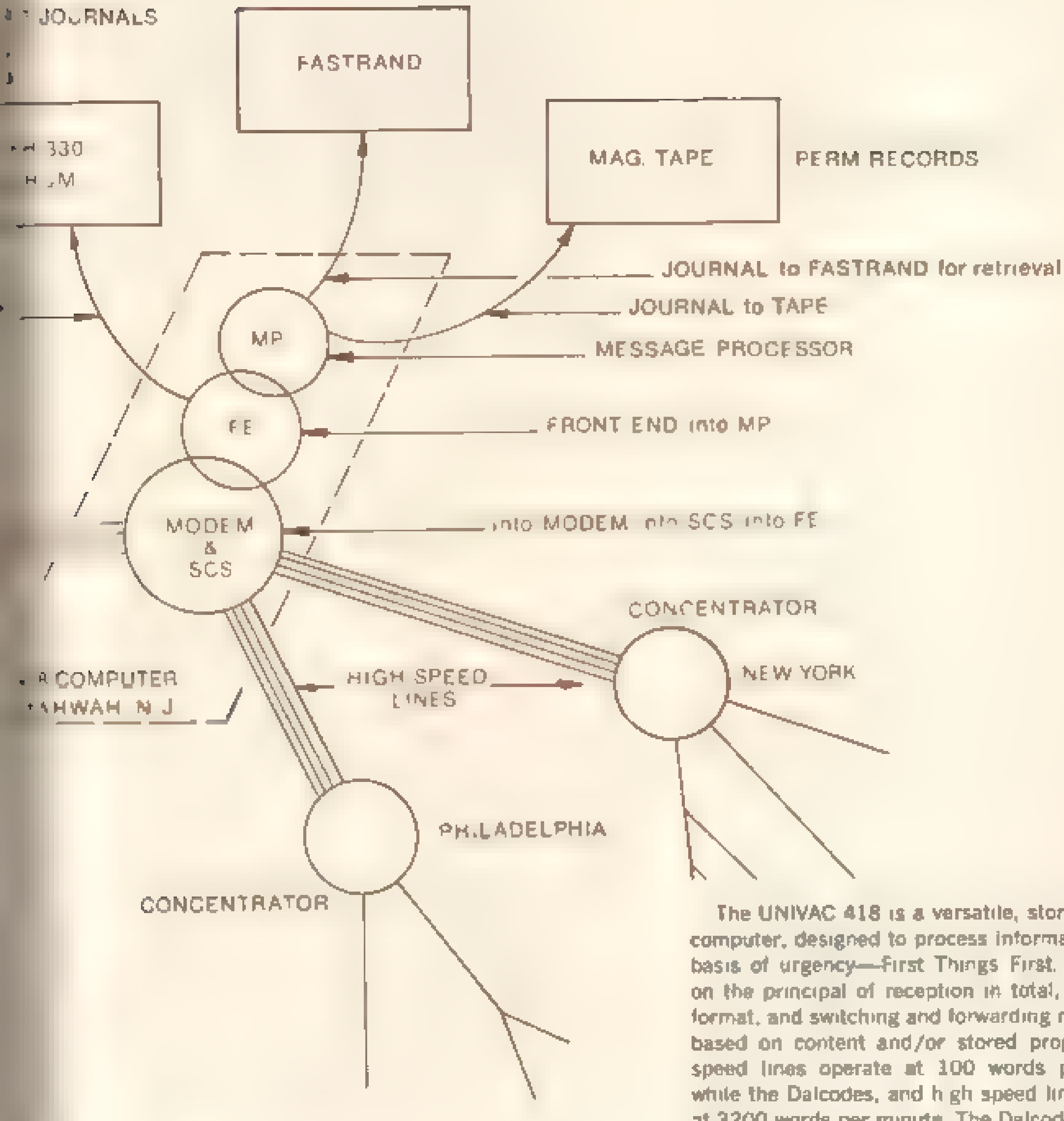


Fig 2—System Network Showing Dalcodes Which Interface High Speed (32000 wpm) Lines with Low Speed (100 wpm) Lines

The UNIVAC 418 is a versatile, stored program computer, designed to process information on the basis of urgency—First Things First. It operates on the principal of reception in total, analysis of format, and switching and forwarding messages—based on content and/or stored programs. Low speed lines operate at 100 words per minute, while the Dalcodes, and high speed lines, operate at 3200 words per minute. The Dalcodes and high speed lines are owned and operated by Western Union. Each Dalcode consists of a Front and a Rear Gate, either of which can back-up the other. High speed lines are voice frequency, having Broad Band, microwave back-ups. The UNIVACs

of course, have 2 back-up computers, thus providing an over-all reliability for the system. For the month of January the SICOM system reliability was 99.2 percent for Shields and Company alone, it was 98.9 percent for the same period—and for the peak market hours of 10 AM to 2 PM, for Shields and Company, it was 99.3 percent. These statistics are based on an 11½ hour day, with a start-up time of 7 AM, and a close-down of 6:30 PM. The computers had a maximum recovery time (or effective outage) of 9 minutes for this period, and a minimum recovery time of 3 minutes.

One computer serves as the selector, and a limited validator (or the Front End), it relays information and messages to the second computer (or Message Processor) for further validation and delivery instructions. In addition to the UNIVACs, an integral part of the complex, is a FASTRAND DRUM, an FH-330 DRUM, and a MAGNETIC TAPE JOURNAL shown in Fig. 1. The Magnetic Tapes serve as the permanent record of Sent and Received messages over the entire system on a *Random* Access basis.

The FH-330 drum provides *Rapid-Access-Storage*, for in-transit messages, and programmed instructions. The fastrand drum provides *Random* Access Storage for the Journals and Logs, and storage for Intercept Traffic. In addition, traffic awaiting station availability notification is stored on the 330 Drum.

Subscriber Stations

A Subscriber Station consists of various Model 28 Teletype equipment. Messages are prepared for transmission on paper tape, and stations are invited to send on a predetermined polling pattern. Messages are delivered according to instructions contained in the Message Header, its content, or Computer Programs, they are addressed directly to their destination, with no provision made for a pattern of delivery for a circuit, with the exception, that the highest priority messages will be delivered to a line, before those of lesser urgency.

The computer checks each message as it is received, and verifies the correctness of the message's formatted areas. If it passes the format check, the MP accepts, and transmits it to its proper destination. If the intended destination is currently engaged, the message will be queued to the appropriate line for delivery when the equipment allows. If, while waiting in queue, a message of greater urgency is transmitted, the message with the highest priority will be delivered first. Messages which do not pass the format validation, are rejected, and a unique Error Message is generated by the Message Processor, as shown in Figure 3.

Figure 3—Error Message is Rejected and noted by Clerk

• No two Subscribers Stations are placed on the same Low Speed Line, thus inhibiting any chance of mis-routing traffic.

• SICOM has the advantage of being able to provide an infinite combination of communications relays within your organization, without the need for manual relay. It permits one or more Floor Stations to receive orders for all Branches, and report directly back, without the need for Order Room intervention. Since orders are received in a clearly defined format, based on the New York Stock Exchange format for teletypewriter networks and are received on pre-printed floor paper, the 30 second execution (from time of receipt on on the floor) is now possible—and a 2 minute execution to and from the branch is not unusual, *regardless* of the actual distance of that branch from New York City.

• Order Rooms, under SICOM, shown in Fig. 4 now revert to their original purpose—namely, the handling of orders, but the method changes slightly. No longer do they sift through hands-ful of orders—choosing which ones to direct to which areas.

• Each Order Clerk now works with his own machine—similar to an individual Floor Booth as shown in Figure 5. Before SICOM, order clerks had their hands full just passing orders and reports back and forth. Now they are free to devote more time to seeing that each customer receives

Figure 4—Order Room Handling Orders at Shields & Company 115 Broadway N.Y.C.

Figure 6—Before SICOM—Order Clerk had to Work until 6 or 7 P.M. to clean up Paper Work

the best execution possible. Under the Plan 115 System, this specialized attention was simply not possible—because of time it took to go back to the branches with standings, etc. Now, standings are sent as a matter of course. Now, Part Order Executions are sent out immediately, whereas before SICOM they were held to completion. Now with SICOM instead of taking until 6 or 7 PM to clean up Branch Order Room paper work, as shown in Fig. 6, order clerks are long gone home by 5 PM.

• Given the capacity, by SICOM, to add and subtract stations at will, to re-arrange your networks almost overnight, and no longer needing to be concerned with over-loaded circuits, it is now possible to provide individual departments with their own machines, as for a Research Department, shown in Figure 7.

Figure 5—Order Clerk Handles His Own Machine Similar to an Individual Floor Booth

Figure 7—Individual Departments, such as Research Department, operate their own Machine

• Each Network Supervisor is kept apprised of the status of his network by the computer. Notifications of traffic over loads by line number are delivered when traffic for a line reaches a certain point.

All of This—is SICOM Today

This is SICOM as it is planned today—and as we, as a customer of Western Union, hope and expect it to perform tomorrow.

Expansion of SICOM

There are many possible areas of expansion of SICOM in the future—Western Union plans encompassed the following areas.

1. SICOM could be most valuable in the Research Opinion polls, and the Over-The-Counter Quote Listings of the SICOM user
2. ORDER MATCH. Western Union is currently engaged in preliminary work in the Order Match area. While no target date has been set for placing it on-line, the general impression is, that it will be available by mid 1970. Order Match will hopefully include.
   a. Price validation of order at entry, based on the closing and/or Last Sale prices, with a variable spread from security to security
   b. A Time-in-Force follow-up notification to the Floors, reminding them at certain intervals, of Immediate or Cancel, Fill or Kill, Opening Only Orders, and the like for which no determination has been reported back. Station and Network over-ride in these areas is being explored.
   c. A re-cap of entered orders, matched with executions after the "Close of the Market."
   d. A re-cap of "PRL" Orders and Reports, which have one side or the other missing, after the Close.
   e. An "Add" and "Out" Listing, after the Close to both the entering location, and the Head Order Clerk. A Monthly Open Order Listing to the Head Clerk and the entering Branch
   f. Maintenance of the Open Order File with regard to Ex-Dividends, Stock Distributions, Stock dividends, etc., and expiring Open Orders
   g. Beyond these, complete Recall, or Re-cap, during the day, of unresolved items—namely unexecuted Day and Open Orders—will be available

Advantages of SICOM

• It provides its subscriber with not 1, but 2 on-line computers, as well as 2 back-up computers—analysis of content—status reports—alternate route of traffic—and in the future—order match. All of these at a reasonable price to the user, and the additional benefit of not requiring an outlay of millions of dollars to create a vast programming department, purchase of equipment, and devotion of huge and valuable areas of floor space to the same end

• It increases the amount of order traffic that can be handled, by a minimum of personnel, reduces the chance of erroneous executions and improves the over-all service to the customer

• Western Union provides the maintenance and repairs to the system equipment. Rather than wasting our time determining the type of difficulty when a problem arises and then deciding which vendor of that equipment to contact for maintenance or repair, one phone call to Western Union assures us that SICOM is repaired and maintenance is continuous

It is not perfect—but then—what is?

It will not solve all our problems—

but it goes a long way

to starting to solve many of them.

All of these advantages govern the amount of revenue received by the brokerage firm—and that—after all—is why we are in business! ■ ■ ■ ■


CIRCUIT No
ALTERNATE MACH
MC McCARLEY-BACK OFF
BM MASON-NORFOLK
BQ MASON-RICHMOND
BZ MASON-PORTSMOUTH
SC SHIELDS-CAGE
SP SHIELDS-P&S
BF MASON-NEWPORT NEWS
BG MASON-WILLIAMSBURG
BW MASON-WASH.
CB ASE #1 MACH: "RO" 629
CD ASE #2 MACH: "RO" 618
CE ASE #3 MACH: "RO" 644
CF ASE #1 MACH: "KSR" 629
CI (38)(40) ASE #2 MACH: "KSR" 618
CR (39)(41) 1410 BWAY, NYC 604
FA 30-1 44 WALL ST, BD RM 630
FR 14 FIFTH AVE NYC
MC SHIELDS-SAN FRANCISCO
NA McCARLEY-BACK OFF
NB NYSE BOOTH "O": "RO"
NC NYSE BOOTH "D": "RO"
ND NYSE BOOTH "O": "KSR"
NL NYSE BOOTH "D": KSR 602
NM NYSE ODD LOTS: "RO" 603
QU NYSE ODD LOTS: "KSR" 603
OTC-QUOTE MACH 617
SB (42) SHIELDS-BOND DEPT 615
SC SHIELDS-CAGE 601
SF (47) MEYERSON-SAN FRANCISCO 185
SP SHIELDS-P&S/STENCIL 601
SR (46) 615

QUEUING THEORY
- A New Management Tool

Basic Phenomenon and Applications

Bernard Rider

Traffic analysis in message switching networks depends upon a discipline known as queuing theory. The highly mathematical nature of this discipline tends to discourage those who are not well versed in mathematics. The purpose of this article is to explain queuing theory in simple terms, using examples from common experience as well as from communications

Queuing theory is one of the many branches of the mathematical theory of probability. Like other probabilistic disciplines, it must be viewed differently from the deterministic sciences so familiar to engineers. A closely controlled experiment involving queuing theory may not produce the same results when repeated. Accordingly, the practitioner of queuing theory devotes himself to predicting average results, and noting the variances from the average

The basic phenomenon of queuing is not mysterious when it is considered in the light of an everyday experience, such as a barber shop. Imagine a barber shop having a single chair. Suppose that the barber can give a haircut in 30 minutes. Suppose also, that customers arrive every 50 minutes, on the average. If their arrivals were evenly spaced, there would never be any waiting. Unfortunately, experience indicates that customer arrivals are spaced irregularly. As a result, they usually expect to wait for a haircut.

even though the barber's average workload is well within his capabilities. Queuing Theory will predict the average number of customers waiting, and the average time required for a customer to complete his visit to the barber shop. This theory will also help in the design of a barber shop where waiting is held to a minimum.

This example serves to illustrate two basic components of Queuing Theory. These are 1) arrival statistics and 2) service statistics.

Arrival Statistics

Arrival statistics are based on the arrival of customers to a barber shop which is analogous to the arrival of messages to a Communications Center.

Evidently, the arrival of customers or messages into a queue cannot be described precisely by deterministic techniques. We can, however, specify an average arrival rate, λ, which equals 1/60 customers per minute. However, this specification is insufficient to characterize the irregular customer arrival periods. For this purpose, the statistical distribution of arrivals, about the average rate, is needed. If customer arrivals are independent of each other, and if the average arrival rate is assumed to be constant, the arrival statistics are described as a Poisson distribution, expressed as:

$$P_t(k) = \frac{(\lambda t)^k}{k!} e^{-\lambda t} \tag{1}$$

where

$P_t(k)$ = probability of "k" arrivals in time, t,

λ = average arrival rate

This distribution is illustrated in Figure 1 for the barber shop where $\lambda = 1/60$ customers arriving per minute. The number arriving during a given time is plotted along the axis of abscissas. The probability of that number arriving is plotted on the axis of ordinates. The distribution is plotted for three periods of 30-, 60-, and 90 minutes. If we measure time from an arbitrary starting point the probability of any number of arrivals within 30 minutes is shown in Figure 1a. It is more likely that none will arrive than any other number. As time progresses, when t = 60 minutes, as shown in Figure 1b, the probability of none

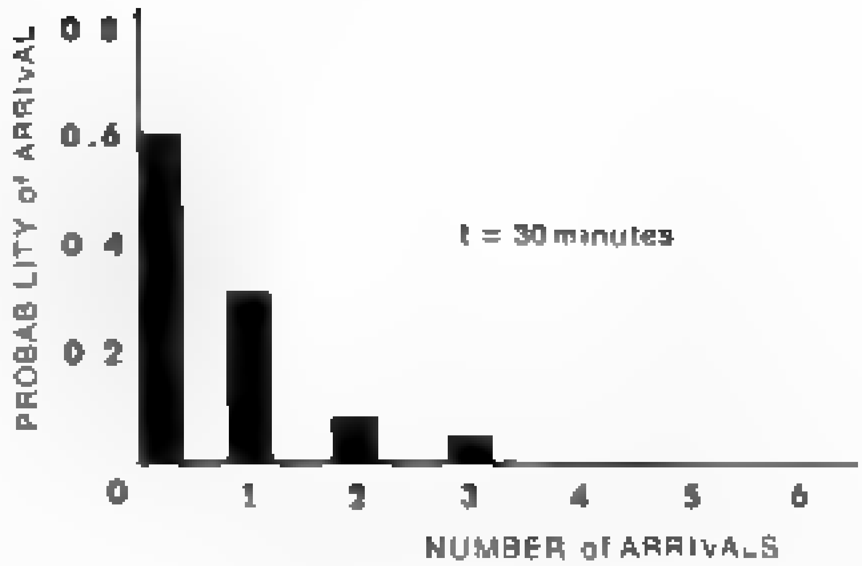


Figure 1a

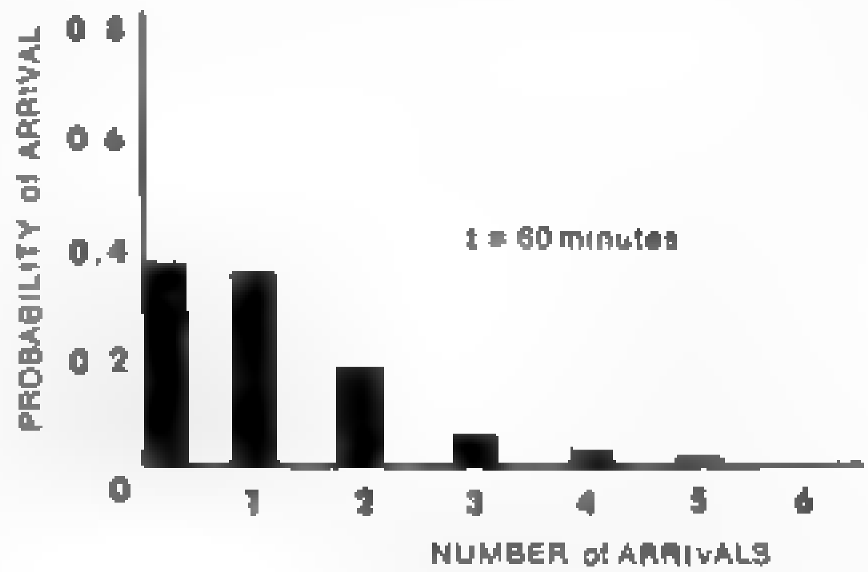


Figure 1b

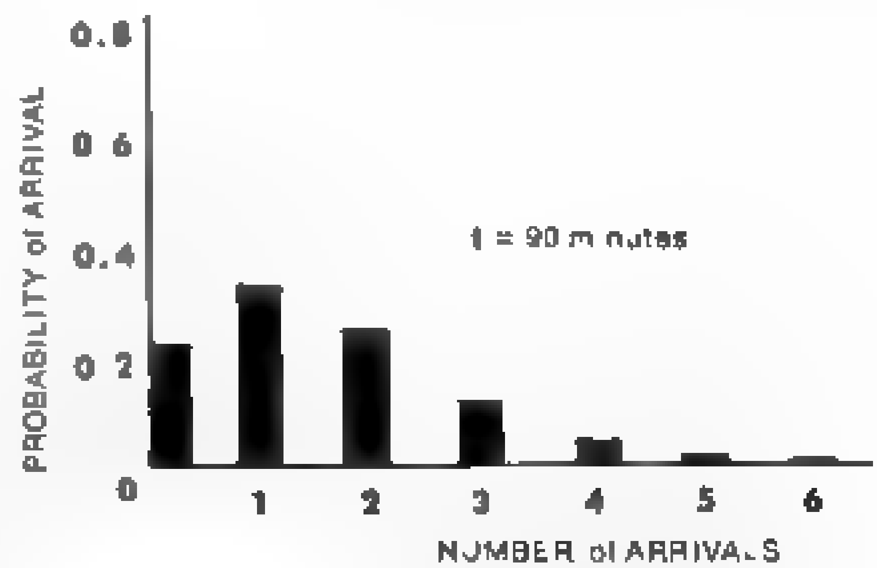


Figure 1c—Poisson Distribution

Figure 1—Arrival Time Distributions for Arrival Rate of 1/60 Customers Per Minute

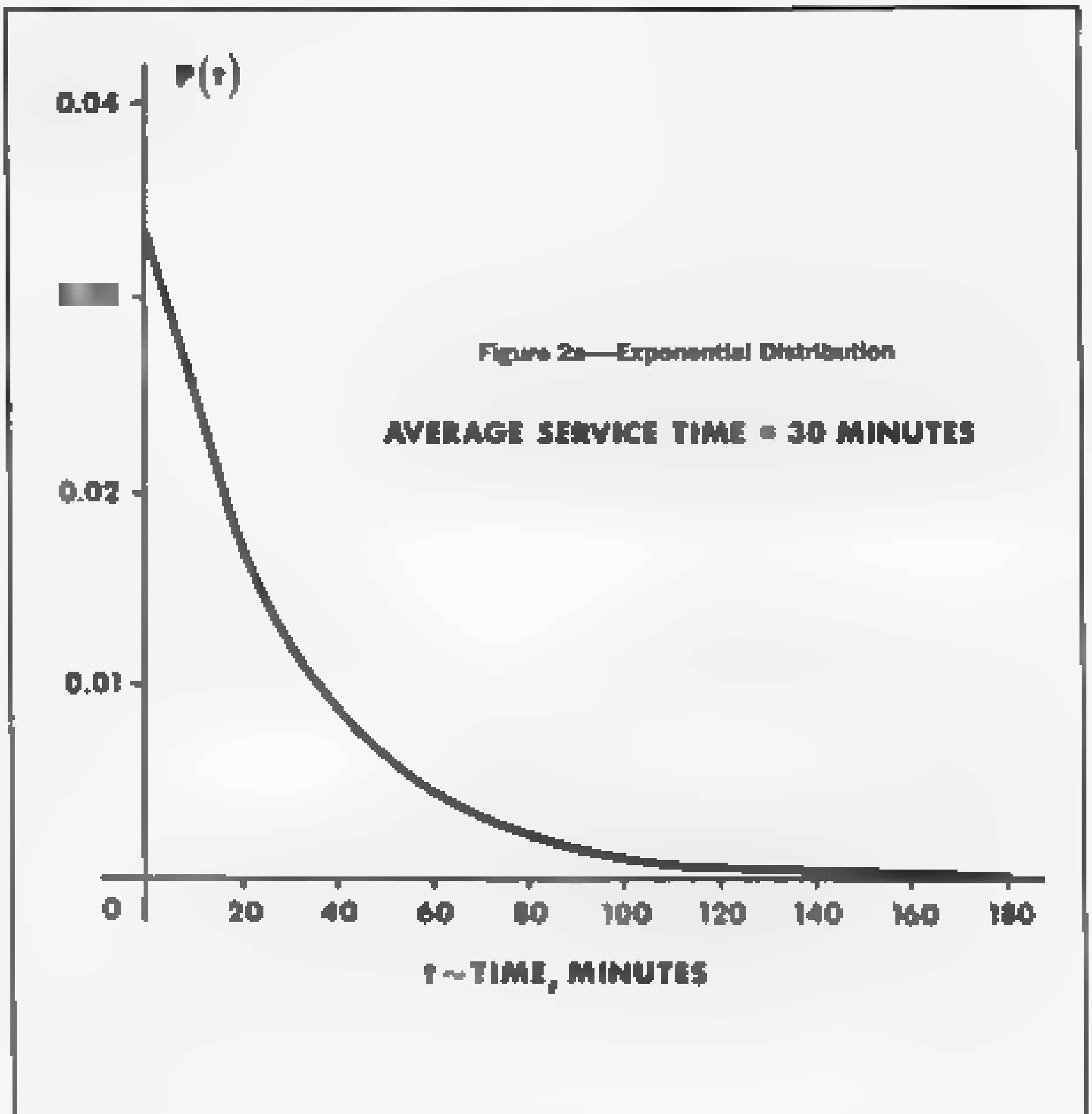


Figure 2a—Exponential Distribution

Figure 2b—Discrete Distribution

Figure 2—Service Time Distributions

arriving diminishes and the probability of one or more arriving increases. This tendency is even more pronounced, when t is 90 minutes, as shown in Figure 1c.

Other arrival statistics are possible. However, the Poisson distribution applies well in so many instances that only its use will be considered here.

Service Statistics

A second factor that contributes to the queuing phenomenon is the distribution of service times or service statistics. Service time is that time required for the customer to complete his business, after waiting for any who preceded him. In the case of the barber shop, it is the time the barber spends with the customer. Customers often require different lengths of times for service. Thus, one hirsute customer may require a haircut and shave, while another baldish type requires only a trim. Return to the original barber shop where the barber required, on the average, 30 minutes to service a customer. To illustrate a point, assume that customers arrive one per hour, exactly on the hour. If all customers required less than 60 minutes for service, there could be no waiting. However, if some require 90 minutes, some 70 minutes, and others less than 60 minutes, there will occasionally be some waiting. This is possible even when the average service time is 30 minutes. Thus, the distribution of service times about the mean average is important to queuing. There are an infinite number of distributions that can be applied to service times, but one most frequently applicable is the exponential distribution shown in Figure 2a, and expressed as.

$$P(t) = \frac{1}{T} e^{-t/T} \qquad (2)$$

where

t = time

T = average service time

This is a "continuous" distribution, used when service times may vary continuously from very short to very long periods. In this respect, it differs from the Poisson distribution, shown in Figure 1, which is a "discrete" distribution.

It is also possible for service times to have a discrete distribution. For example, there is the case where all service times are identical. Then, a constant service time distribution, which is also discrete, is used, as shown in Figure 2b.

For the purposes of this article, the exponential distribution will be assumed. This distribution represents the relative frequency of various service times. Note that service times less than average occur more frequently than those greater than average, as shown in Figure 2a. The average and the median are not always the same. While this may appear peculiar, actual measurements of message lengths in telephone and record systems indicate that the exponential distribution applies. It is also applicable in many other cases.

Analysis of the System

Certain terminology is used in the literature on queues. This can be explained by reference to a multichair barber shop. Customers in the barber chairs are said to be "in service." Those waiting for barber service are said to be "in queue." The sum of all those in service and those in queue, namely, all of the customers in the barber shop, are said to be in the "system."

Customers in a communication system are said to be "in service" when they are transmitting messages on the communications line. Customers "in queue" in a communications system are those waiting to transmit a message, or waiting until the communications line or channel is free to serve them. The total number of customers in a communication system are those "in service" in the line plus those waiting or "in queue" to get "on the line."

To analyze a queue, it is necessary to first determine the probability that there are "k" customers in the "system." The arrival time and service time distributions are used for this purpose. A further assumption is made; namely, that the queue is in equilibrium (i.e., the probability of "k" customers in the system is independent of time). Manipulation of these assumptions will not be explained here; the results, however, are relatively simple, and will be shown.

A parameter which will occur in all of these results is channel utilization

$$\rho = \lambda T \qquad (3)$$

where

λ = average arrival rate in units per second

T = average service time in seconds

The quantity ρ is a measure of the efficiency of use of the service facility.

In communications systems, ρ, is expressed in terms of the erlang, although it is a dimensionless quantity. Here, we will assume that $\rho < 1$, otherwise when $\rho > 1$, the system is overloaded and the queue will never reach equilibrium.

Single Channel System

Now if we consider a single-channel system—one with a single service facility or a single-chair barber shop, the expression for the average number of arrivals to the system is

$$\bar{n} = \frac{\rho}{1-\rho} \tag{4}$$

This expression is plotted in Figure 3. For values of ρ below 0.5, there are fewer than one unit, on the average. As ρ increases above 0.5 the number in the system increases above unity. The curve approaches infinity as ρ approaches unity. The asymptotic behavior of the curve, as ρ approaches 1, is consistent with the assumption that the queue must be in equilibrium.

The average time a unit spends in the "system" is expressed as

$$T = \frac{\bar{n}}{\lambda} \tag{5}$$

Example 1 (Barber Shop)

Let us now apply these results to the barber shop problem, where

$\lambda = 1/60$ customers/minute

$T = 30$ minutes

Using equations (3) we obtain $\rho = 0.5$. Substituting this result in equation (4) yields $\bar{n} = 1$ customer. Finally from equation (5) we find that the average time spent on the system, is 60 minutes $T = 60$ minutes. Thus, we can expect to find one customer in the barber shop, and we can expect to wait a total of 60 minutes from the time we enter until we leave. If the customer arrival rate increases to one every 45 minutes, the same equations tell us that the average number in the shop will increase to 2 and that the average time spent in the shop will be 90 minutes.

Example 2 (Communication System)

An analogous situation exists in communications systems where, in a message switching computer, arriving messages queue up for access to an output circuit. In this case, the average service time, T, is equal to the message transmission time; that is,

$$T = \frac{L}{C} \tag{6}$$

where

L = average message length in bits

C = channel speed in bits per second

The channel utilization can then be expressed as

$$\rho = \frac{\lambda L}{C} \text{ erlangs} \tag{7}$$

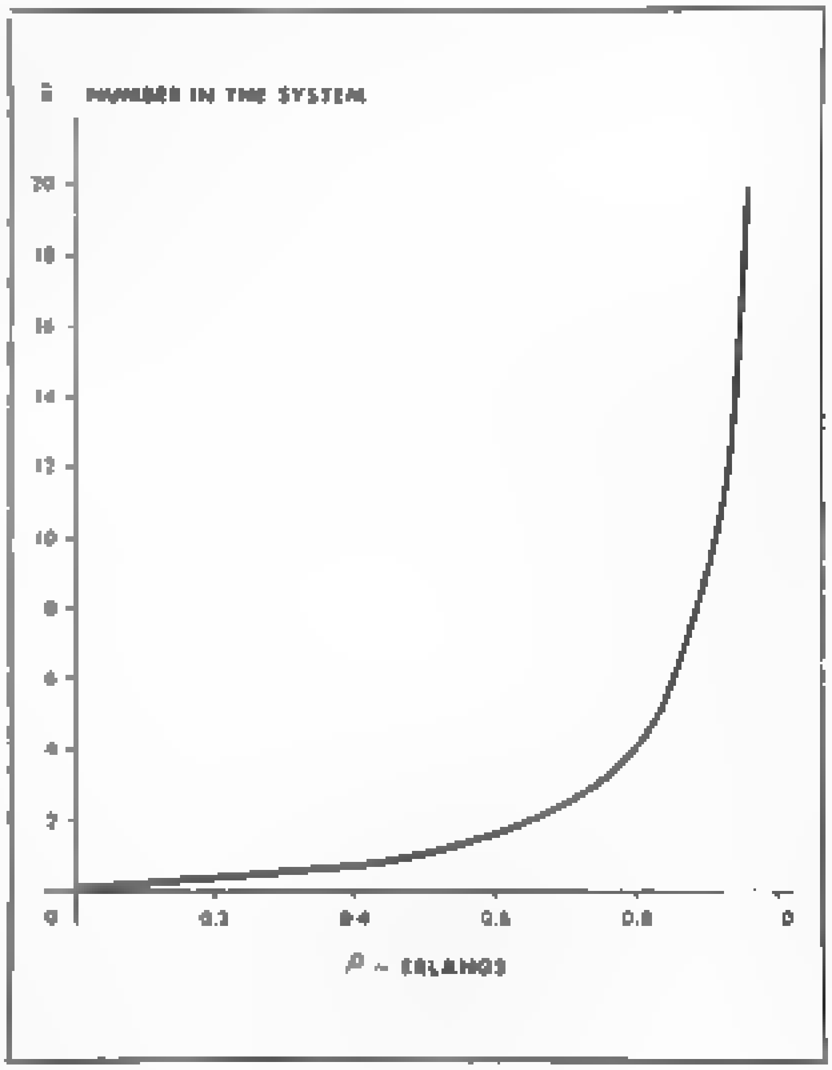


Figure 3—Single Channel System

Plot of

$$\bar{n} = \frac{\rho}{1-\rho}$$

Consider a 75 bit-per-second output channel. Messages addressed to this channel arrive at an average of 0.08 per second. Their average length is 750 bits. From equation (7), $\rho = 0.8$ erlang. Substituting this result in equation (4) we find an average of four messages in the system (waiting and being serviced). From equation (5), we

determ ne that the average message delay, or the average time in a communication system, is 50 seconds.

Example 3 (Communication System)

If, in the preceding example, the channel speed is increased to 150 bits per second, calculations show that the average number in the system, s reduced to two-th rds of a message and that the average delay is reduced to 8 35 seconds. In th s case, doubling the line speed causes the average number in the system and the average de ay to be reduced by a factor of 6.

Many queuing systems are multichannel (i.e., have more than one service facility). An example is a barber shop having several chairs. If we assume that the customer will be served by the first available barber, the following equation gives us the average number in the system:

$$\bar{n} = \rho + G\frac{\rho^M}{M!}\frac{\frac{\rho}{M}}{\left(1-\frac{\rho}{M}\right)^2} \tag{8}$$

where

$$G = \frac{1}{\frac{\rho^M}{M!}\left[\frac{1}{1-\frac{\rho}{M}}\right] + \sum_{k=0}^{M-1}\frac{\rho^k}{M!}} \tag{9}$$

and where

M = number of channels

Equat ons (3), (5), (6), and (7) also apply to the multichannel case. For a multichannel system, it is possible that $\rho > 1$ without violating the equilibrium assumption. In this case $\frac{\rho}{M} < 1$ is the requirement.

Equation (8) is illustrated in Figure 4 where $\bar{n}$ is plotted versus ρ, for several Ms. Note that the curves approach infinity as $\frac{\rho}{M}$ approaches unity. Because the equations for the multichannel case are rather complex, the curves of Figure 4 can be used for ca culations.

Route Selection

Example 4 (Communication System)

Messages dest ned for a particular location arrive at the rate of 0 8 per second. Their average length is 750 bits. They are routed over a group of ten trunks, with each trunk having a speed of 75 bits per second Summarizing: $\lambda = 0.8$ message per second, L = 750 b ts, C = 75 bits per second, M = 10

Using equation (7) we find ρ = 8 er angs

From Figure (4), n 9 6 messages.

From equation (5)

the message delay, t, = 12 seconds

The results of Example 4 may now be contrasted with those of Example 2 to illustrate an interesting point In Example 4, an incoming message was routed to any one of ten trunks. If the results of Example 2 are repeated ten times, we see what occurs when the messages are addressed to individual circuits and the circu t addresses are equally distributed among the

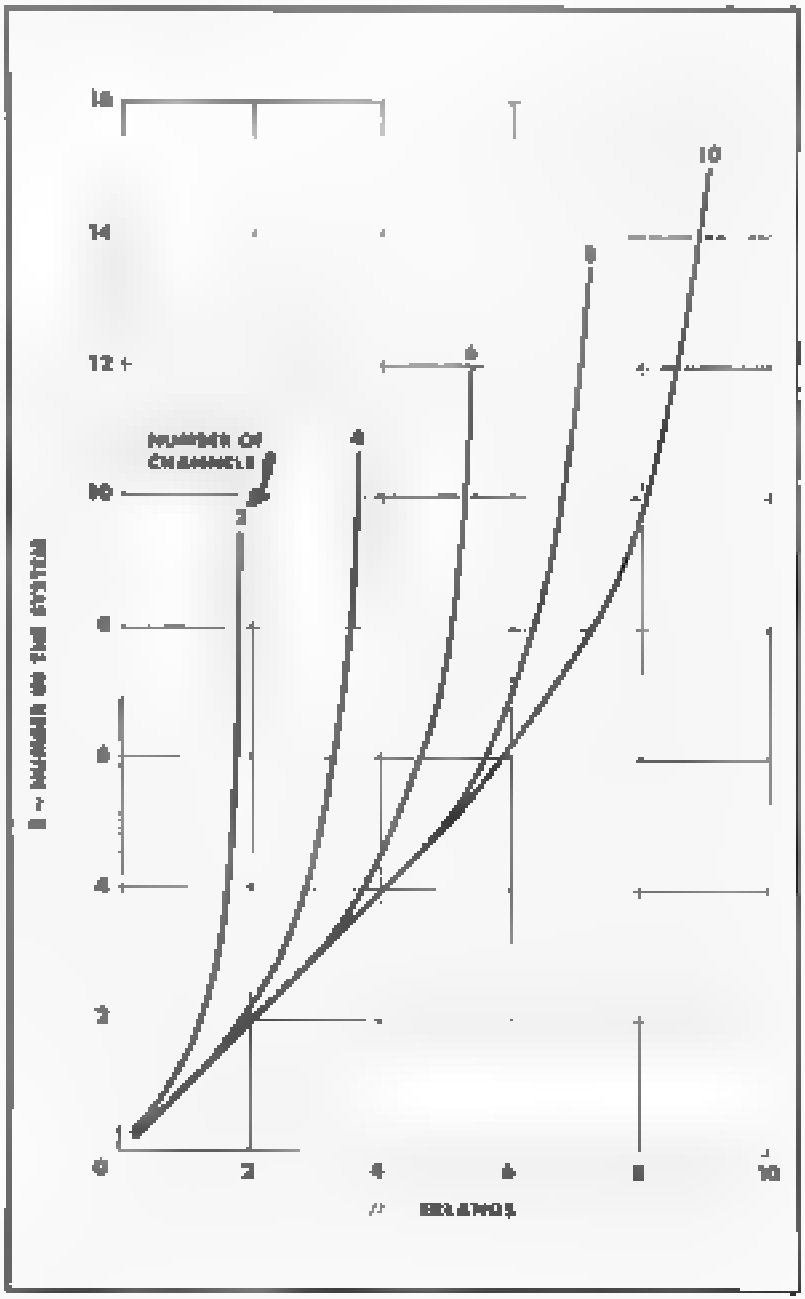


Figure 4—Multi Channel System

messages, as shown in Figure 5. The situation is analogous to two 10-chair barber shops. In one shop, the customers take the first available barber. In the second, each customer waits for his favorite barber, since the barbers are equally popular. As we might expect, delays are longer when we allow ourselves the luxury of selecting a barber.

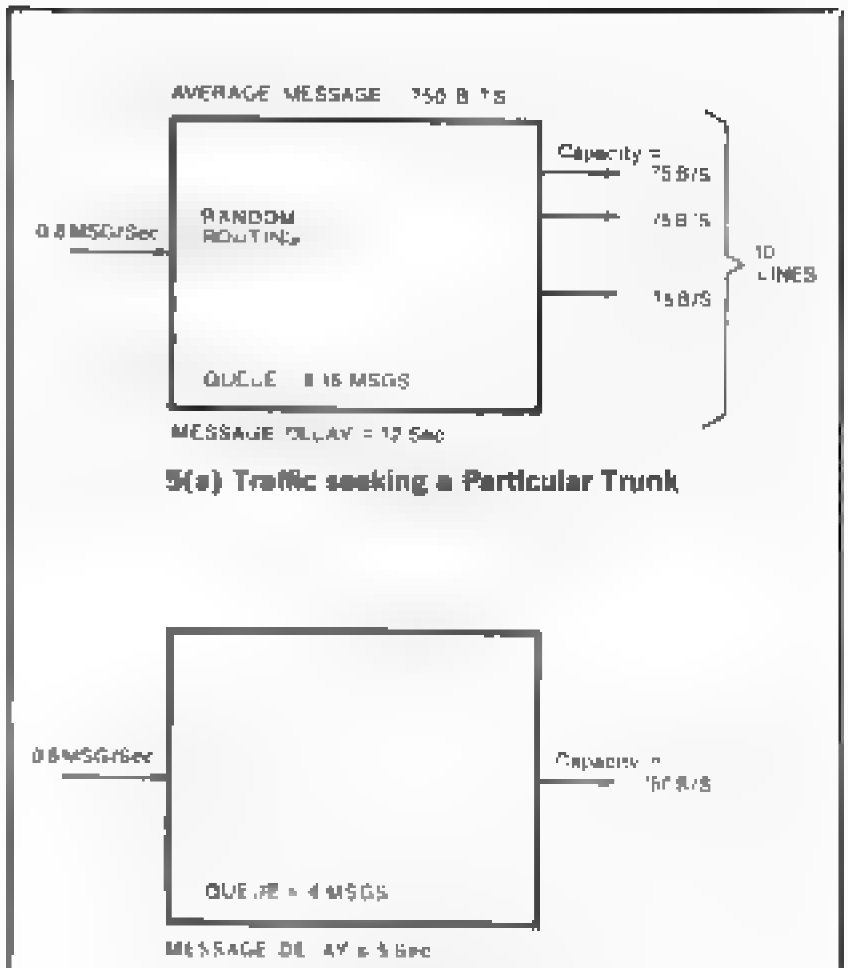
This phenomenon has ramifications in communications networks.

Barber Shop vs. Communications System

The results of Example 4 may also be contrasted with those of a single-channel system having a capacity equal to that of all ten channels of Example 4, namely 750 bits per second. The results are illustrated in Figure 6, showing the effect of Traffic Concentration. It is surprising to note that queues and delays are smaller for the single-channel system than for the 10-channel system. This result is general and not limited to the number of channels in the system. It indicates the benefits of concentrating traffic on high-speed channels.

The corresponding situation in everyday life, the Barber Shop, is an affront to intuition. It indicates that a single barber, who can give an average haircut in 6 minutes, will provide faster service than ten barbers, each giving an average haircut in 60 minutes. A closer analysis of the problem indicates that the single barber will have more customers in his "queue" than will the ten barbers. However, he will have fewer customers "in service," and his improvement in "service time" will more than compensate for the queue. As a result, there will be fewer customers in his shop, and their waiting time will be less. Results that defy intuition are not infrequent in the probabilistic sciences. They often indicate a lack of sophistication in intuition in these fields rather than an error in the calculations.

So far, we have been concerned with the average number of units in the system. In practice, we must cater to numbers that are larger than the average. A barber who has room in his shop for only the average number of customers he expects will soon find that his expectations have been optimistic. When more than the average number



5(a) Traffic seeking a Particular Trunk

5(b)—Traffic seeking any Trunk

Figure 5—Effects of Route Selection

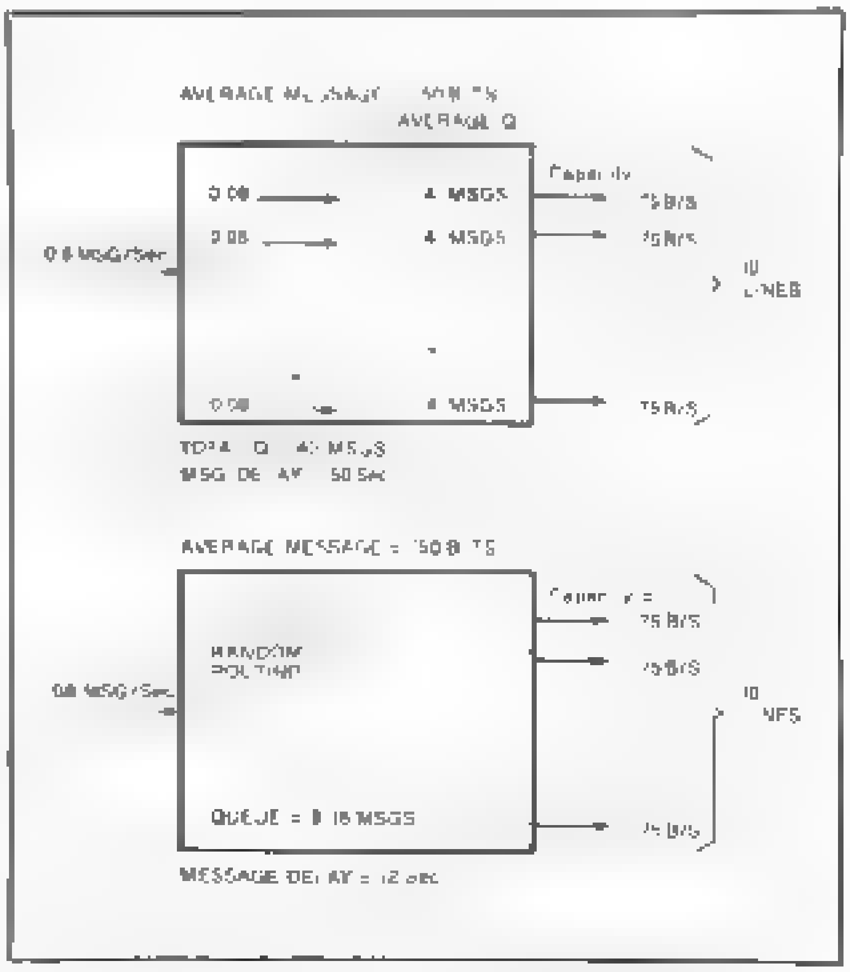


Figure 6—Effects of Traffic Concentration

of customers must wait, and there is no room in the shop, a new phenomenon, known as customer resistance, has the effect of reducing sales.

Similarly, in a communications network, we must supply more buffer storage area than is required merely for average conditions. For single-channel systems, the probability of finding more than N customers in the system is

$$P(>)N = \rho^{N+1} \qquad (10)$$

This Probability of Overflow is plotted in Figure 7 for the conditions set forth in Example 1. Figure 7 shows that a shop with a capacity for only one customer (the average number) will overflow 25 percent of the time. However, a shop with a capacity for three customers will overflow only about 6 percent of the time. While the curve in Figure 7 appears to approach zero, in fact it is asymptotic. One can never be certain that his shop will be large enough to accommodate all arriving customers. However, it is possible to provide enough space to guarantee any specified probability of overflow.

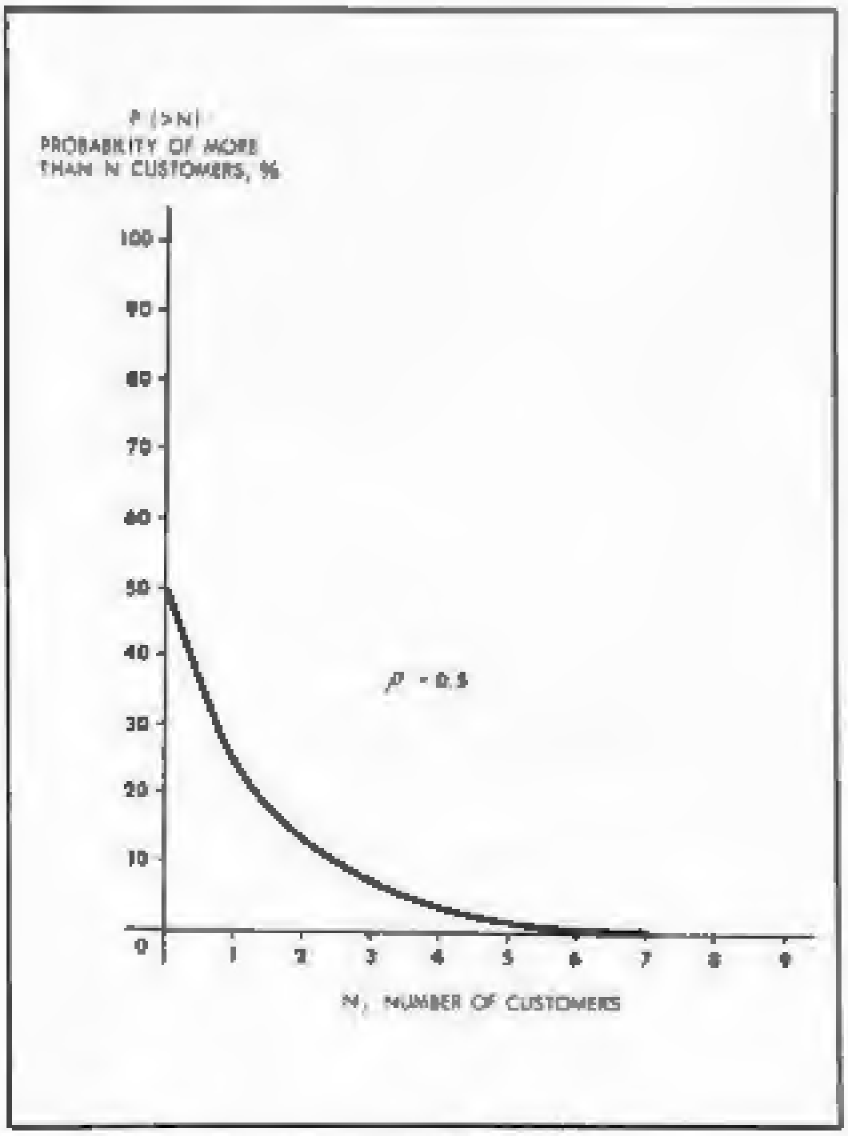


Figure 7—Probability of Overflow

Queuing theory has obvious application to supermarket checkout counters, air traffic control and communications. A less obvious application is logistics.

Application

There are many applications for queuing theory in communications systems. These include analysis of both computerized and manual switching centers, and the planning of improved logistics procedures.

Suppose it is necessary to keep three machines operational in a location served by a single maintenance man. The mean time between machine failures is 10 hours. The average repair time is 1 hour. How many spares must be stocked at this location to provide at least a 90 percent probability that three machines will be operational? This problem can be solved by applying queuing theory principles to the system logistic model, in Figure 8. The results are tabulated below.

Number of Spares	Probability of 3 Machines "Up" (percent)
0	73.2
1	92.2
2	98.5

Only one spare machine is required to provide the desired level of operational continuity.

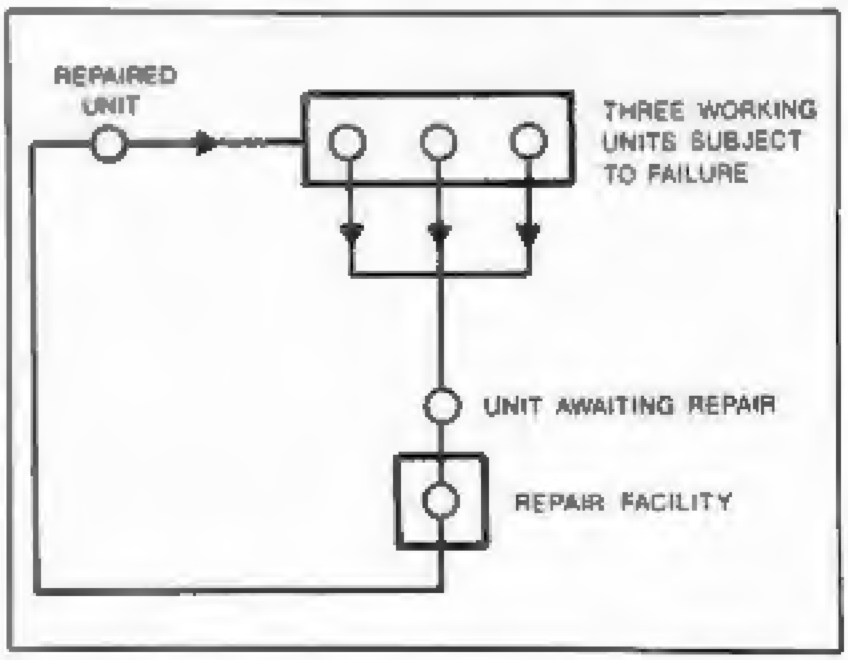
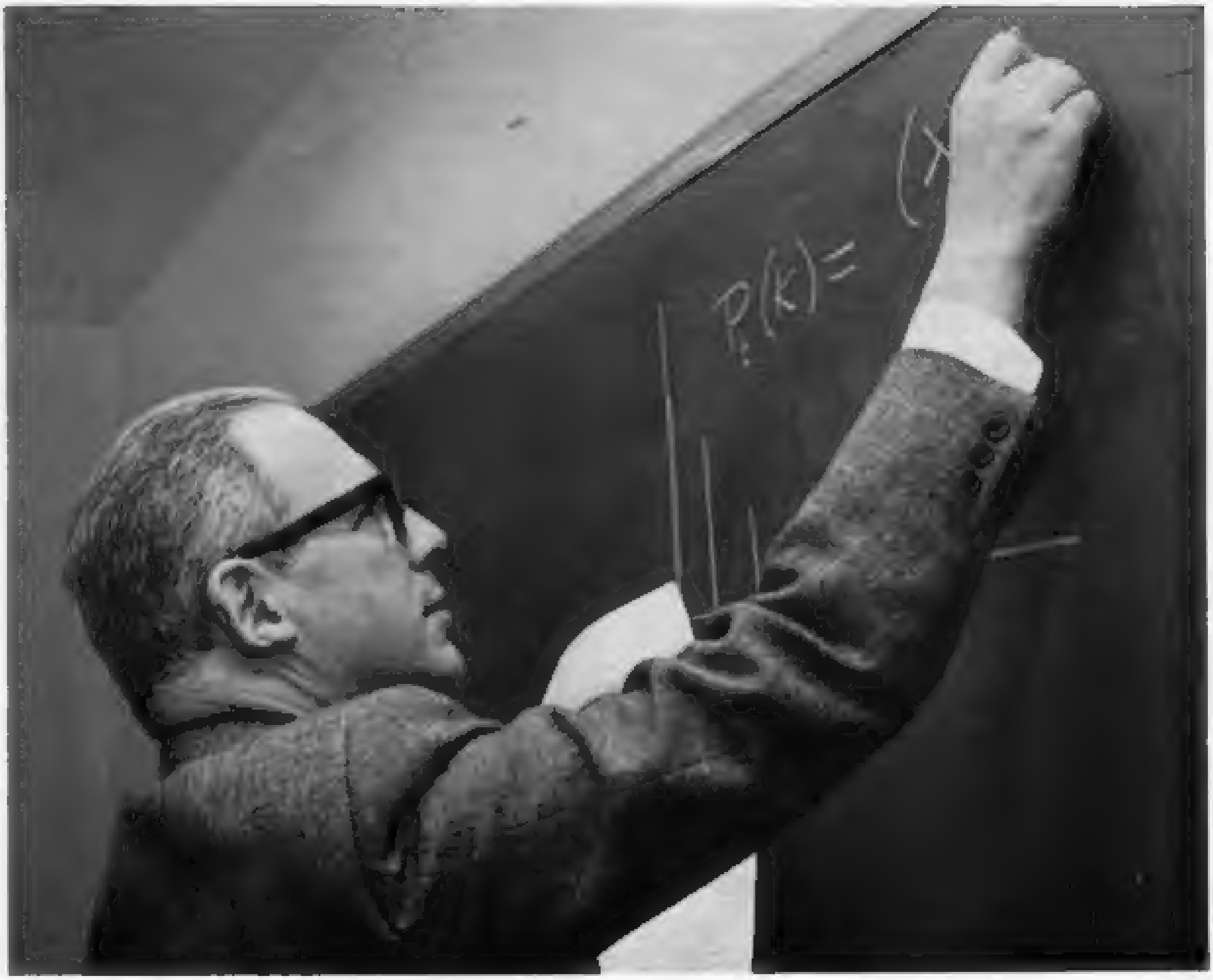


Figure 8—Closed Loop Logistic Model for 3 Spares

A New Management Tool

Queuing theory is rapidly becoming an important tool of modern management. ■ ■ ■ ■



Bernard Rider, Assistant Vice President in the Government Communications Department of Western Union in Arlington, Va., has specialized in the analyses of communication system traffic and queuing problems for some time.

His experience in applications engineering and communications system design in addition to his many years of teaching, has prompted the writing of the article on pg. 150 entitled "Queuing Theory."

Mr. Rider received his M.E. degree in 1944 and his M.S. degree in 1946 from Stevens Institute of Technology and was active in teaching programs at Massachusetts Institute of Technology from 1946 to 1956.

Mr. Rider has recently been made President of American Communications Corporation in Arlington, Va., a subsidiary associated with Western Union.

Book Review

Editor's Note: Because of the interest in Queuing Theory and its many applications to Western Union Systems, this book review was selected to follow the article on Queuing Theory.

Introduction to Elementary Queuing Theory and Telephone Traffic by Petr Beckmann, The Golem Press, Boulder, Colorado 1968 (144 pp.)

The objective of the book, as stated in its preface, is "to bridge the gap separating the beginner from these more meritorious texts." (The author refers to those texts currently available.) The author assumes that the reader has had courses in Calculus and elementary Probability Theory. In the opinion of the TECHNICAL REVIEW, the author has indeed achieved his objective, since virtually all texts available on Queuing Theory seem intended primarily for those who are already familiar with the subject, or who have extensive related background. There are some areas of this book where improvement seems possible; these will be pointed out. Generally speaking, however, Beckmann's book is remarkable for its colorful, logical, and understandable approach to an esoteric subject.

Chapter I, Introduction, describes the general problems to be solved and the terminology to be used. Interesting, as well as informative, it will inspire the reader to continue.

Chapter II is a review of some basic formulas of Probability that will be referenced in later chapters. Unless the reader is very well grounded in Probability Theory, reference to other texts is desirable.

Chapter III is concerned with the Poisson distribution, used throughout the text to describe arrival statistics. The distribution is derived from the basic principles touched upon in Chapter II. A set of brackets is omitted in equation (10) of Chapter III which causes several succeeding statements to appear to have a mysterious origin.

The exponential distribution is discussed in Chapter IV. It is derived from basic principles using the Poisson distribution. This explanation is unusually lucid. The stage is now set for an analysis of queuing and other traffic phenomena, since the text assumes that service times are exponentially distributed.

Chapters V, VII, VIII, and IX present single and multiple channel loss and delay systems. Great emphasis is placed upon a methodical derivation of the steady state system equations. With this background, the reader should be capable of deriving these equations for cases not described in the text. Chapter VI describes the application of the general theory to telephone systems and shows the relationship between various units of traffic.

Chapter X is concerned with obtaining expressions for the service facility loading efficiency of loss and delay systems. The results are qualitatively related to economic factors which must be applied in practical cases.

Chapter XI and XII are concerned with delay distributions for queuing systems. This is a difficult topic which is discussed with reasonable clarity. However, the more leisurely methodical approach Beckmann used in earlier chapters would have been welcome.

Chapter XIII provides suggestions for further study with a bibliography.

Various graphs and tables are provided in the book. Its illustrative problems and exercises at the end of each chapter are notable for their practicality and interest.

Perhaps the most startling aspect of the book is the fact that the author has packed so much material, yet so much lucidity, into 125 pages of text (excluding tables).

B. Rider

ABSTRACTS OF ARTICLES IN SUMMER 1969 ISSUE
of the
WESTERN UNION TECHNICAL REVIEW

Hildreth, A. E.: NCIC Information Retrieval System Uses Western Union Terminals and Circuits

Western Union TECHNICAL REVIEW, Vol. 23, No. 4 (Summer 1969) pp. 130 to 135

Western Union provides some of the terminal equipment and all the circuits for the new Information Retrieval System installed, in January 1967, for the National Crime Information Center at Washington, D. C. Terminals at federal, state and local law enforcement agencies may be a Western Union terminal, an IBM terminal, or a computer. They provide remote access to the NCIC computer for retrieving information, for entering data and for updating old data.

Each terminal is connected to the NCIC computer by circuits provided by Western Union.

This article describes the components of the Western Union terminal and the control sequences used in the messages.

The National Crime Information Center is a valuable tool for law enforcement agencies. Western Union circuits and terminal equipment extends its service to its agencies quickly and easily.

Parowski, S. C.: Test Facility—A Unique Measurement Tool

Western Union TECHNICAL REVIEW, Vol. 23, No. 4 (Summer 1969) pp. 136 to 141

Western Union developed a unique Test Facility to measure the channel transmission of its existing plant. Digital data error statistics and channel analog performance are recorded simultaneously by an on-line digital computer.

This facility located at Western Union's headquarters is capable of obtaining error statistics resolved to a single bit.

This article describes the Special Features of the Test Facility, the software package and includes graphs of some of the data collected.

This facility has proven to be a useful tool, in determining the performance of Western Union data circuits.

Dailey, Joan C. (Shields & Company): The First Customer on Wall Street to Cut-Over to SICOM

Western Union TECHNICAL REVIEW, Vol. 23, No. 4 (Summer 1969) pp. 142 to 149

The article describes the need for SICOM in the Financial District in New York City and why Shields & Company, brokerage house on Wall Street, decided to use SICOM, Western Union's new service.

SICOM Today and SICOM as planned for the Future are described. A block diagram of the operation is included as well as a description of the subscriber stations. The advantages of SICOM are pointed out as governing the amount of revenue received by the brokerage firm.

Rider, Bernard: Queuing Theory—A New Management Tool

Western Union TECHNICAL REVIEW, Vol. 23, No. 4 (Summer 1969) pp. 150 to 158

The basic phenomenon of queuing is not unfamiliar to many engineers. While this article is somewhat tutorial in nature, it does illustrate the comparison of the everyday arrival of customers to a barber shop to the arrival of messages to a Communications Center. Certain terminology used in the literature on "queues" is equally applicable to communication service. Examples of barber shop "queues" and communication system "queues" are cited.

Queuing theory has many applications in Communication Systems.